Tork-Trak©TM User Manual

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COOPER PowerTools

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SECTION 1

Introduction to the Tork-Trak TM Controller

The Tork-Trak TM Fastening Controller (T3M) is a single channel nutrunner controller with software capability to run additional tools by connecting to satellite servo modules. The T3M controller is the fifth generation design of this product and provides greater functionality than earlier models. A number of improvements have been added. The basic design of the TM3 controller includes the functionality of the Cooper Power Tool TM Servo Module combined with a Celeron CPU running TM Multi-Trak Software.

Control signals from the CPU command the Servo Module which in turn controls the nutrunner to achieve user-programmable torque and angle targets. Statistical results are saved, calculated, sorted and can be viewed on screen. In addition, the controller can be used for joint analysis by displaying or saving a digital file of torque vs. angle fastening rundown O'scope graphics which can be read or printed by any laptop or desktop computer. The high resolution LCD display provides the user with multi-color graphics supporting a wide variety of fastening system applications.

Some of the features of the T3M controller include:

- NEMA 12 enclosure design
- TM Multi-Trak software which is the same software used on Cooper Power Tools Automated Systems multiple-spindle panels, so there's no need to learn different programming procedures on fixtured tools and handtools.
- Improved PC/104 Celeron CPU with extremely compact design, lower power consumption, wide operating temperature range, and very high reliability.
- Improved Servo Amplifier design with accurate speed control as low as 3 rpm through max speed. The new servo amplifier integrates transducer and resolver measurements with the servo power functions within a single compact module.
- Remote I/O support which has optically isolated inputs and relay contact outputs which are externally accessible fuse protected,.
- New firmware support which includes global memory, graphical fastening strategy programming screens supporting Torque Control, Angle Control, Self-Tap, Prevailing Torque and Yield fastening strategies.
- Software support to permit synchronization of multiple Tork-Trak servos for multi-spindle applications.
- Increased support for an unlimited number of Applications.
- Communications support for USB, EtherNet, Fieldbus and 2 channel Ethernet carrying Data and Virtual I/O

Ease of Programming

Cooper Power Tools Automated Systems has designed the Tork-Trak TM to provide an intuitive programming environment which helps reduce errors. The main features of the Tork-Trak TM which simplify and reduce your programming time are:

- The Tool Library.
- Support of tools with memory chip.
- Graphical display of Fastening Curves and Set Points.
- Ability to edit the program while continuing to perform fastening rundowns.
- Statistics Reporting
- Internal O'Scope function for joint and process analysis
- Histogram, X-bar and Range charts for process control.
- Diagnostics for tool, transducer and communications.

Tool Library

The Tork-Trak TM provides a (user programmable) tool library containing setup information for every electric tool manufactured by Cooper Power Tools. If the tool is equipped with a memory chip, the tool automatically identifies itself to the CPU and uploads the tool parameters. If the tool does not have a memory chip, the Tool Library can be manually accessed to install the correct tool parameters by choosing the tool Model Number. After selecting a tool from the library, the Tork-Trak TM automatically programs the appropriate torque transducer and angle encoder calibration values for that nutrunner.

LCD Display Graphics

The Tork-Trak has an LCD display using TFT LCD technology and high speed video communication with a resolution of 1024 by 768 pixels. This display also provides the user with the ability to view an 8 ½ inch screen in full color with graphical representations of torque curves and set points. Screens which graphically represent the Torque/Angle curves allow you to edit set points for your specific fastening application.

Fastening Strategies

The power of Cooper Automation's TM Servo Module allows you to program theTork-Trak for basic or advanced fastening strategies. The following fastening strategies are available and easy to program and are a subset of the two dozen available fastening strategies.

- Torque Monitor
- Torque Control / Angle Monitor
- Angle Control / Torque Monitor
- Prevailing Torque Monitor
- Yield Point Control
- Yield Point Control with Gradient Monitoring

Statistics Reporting

The Statistical Process Control functions of the Tork-Trak TM controller are capable of meeting your present production demands today and years into the future. The RUN Screen dynamically indicates Torque X-bar, Range, Sample Number, Sample Size and CpK after every fastening rundown. The Stats Menu and Print Menu screens offer custom format options which allow you to produce reports specific to your needs:

- Statistics Report
- Application History Report
- Chronological History Report
- Histogram
- X-bar and Range Charts
- Fault Log

Other Features

Diagnostics

- Torque/Angle Curve (O'scope Curve)
- Tool Tests
- Tork-Trak Self Tests
- Fault Log

Outputs

- EtherNet port
- USB port
- Field Bus Support of Devicenet, Profibus or Interbus (options)
- Six Fastening Accept / Reject Indicator Lights + Two User programmable Indicator Lights

Peripherals

- External Keyboard connector

Options

- Public I/O port and matching cable connector
- RS-232 Serial Connector port
- Laser Bar Code Reader
- External Application selector switch
- External control pendant
- External socket tray
- Batch Counting Capability
- Remote Light Box
- Remote Live Handle for Cycle Start
- Stack Light Connector Support
- GM Common Controller
- DeviceNet
- Profibus
- Interbus
- Ethernet IP
- Modbus TCP
- Interbus 2 channel Data + Virtual I-O

Unpacking

The Tork-Trak TM controller is a fastening system with a minimum of components. In its basic form, the system consists of the Tork-Trak TM controller enclosure, the fastening tool and a field cable. During unpacking it is advisable to inspect the equipment for damage which may have occurred in transit and also to verify that the expected equipment has actually been received. Check that you have received the proper tool model and the correct field cable length, as well as any optional equipment you may have ordered. The first step is to remove the Tork-Trak TM controller unit from its shipping carton.

Installation

The Tork-Trak TM controller requires a secure mounting surface capable of supporting weight of approximately 40 pounds. The selected location should be in an unobstructed area offering a clear view of the indicator lights and LCD display, and access to the supplied keyboard. Mount the unit away from major electrical systems, electric motors, arc welders, and areas experiencing excessive vibration, moisture and heat. Install the Tork-Trak TM controller utilizing the bolt template provided in Figure 1-1 and allow 12 inches of clearance on the bottom front of the unit for cable connection accessibility. Mount the unit with four 1/4 inch diameter bolts.

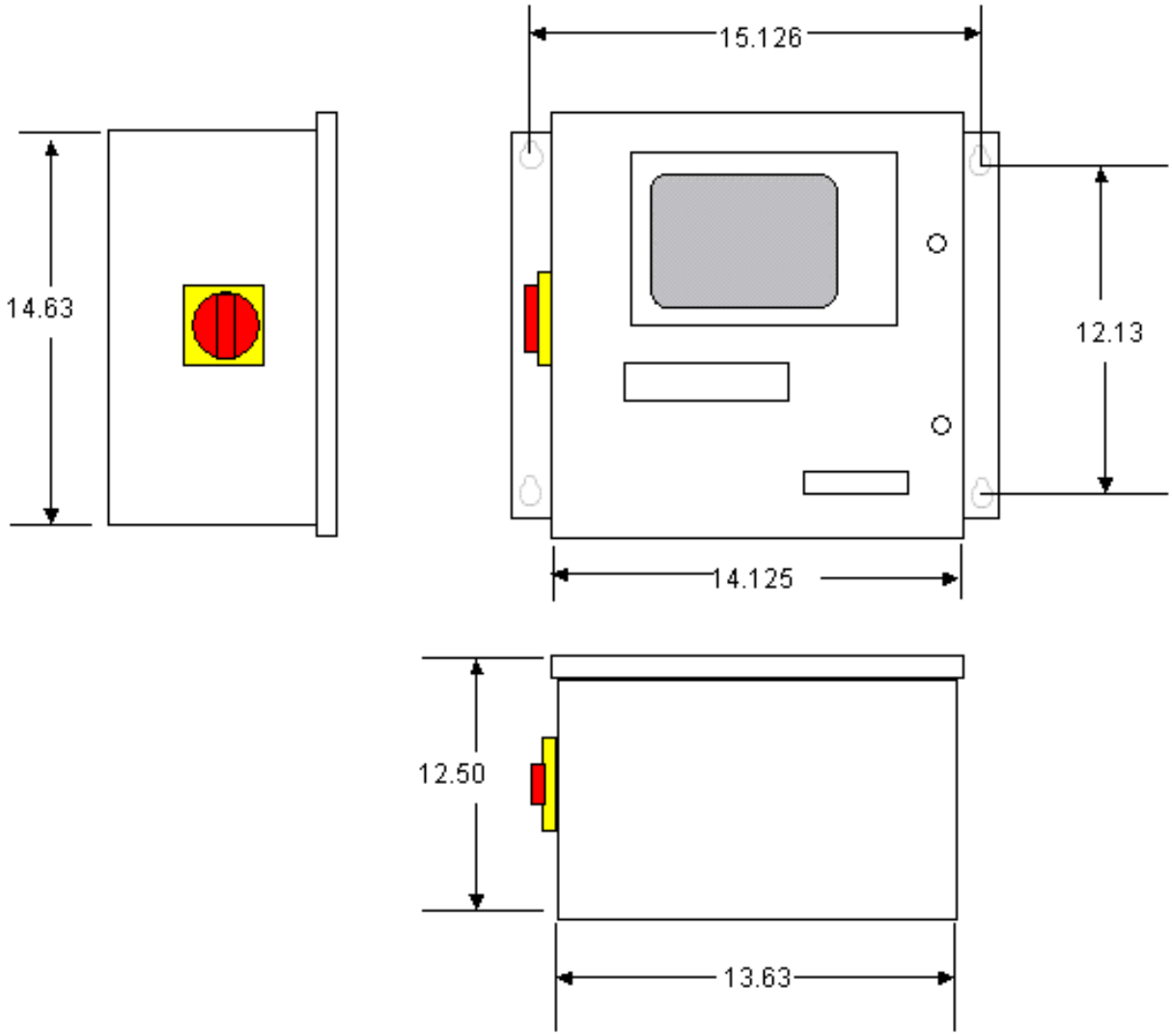


Figure 1-1 T3M Enclosure Outline and Mounting Dimensions

Connecting the Tool

The field cable and tool can now be connected to the Tork-Trak TM controller. Proper engagement of the cable connectors is important. Carefully align the connectors and the lock ring while firmly pushing the connector until it is fully seated. Excessive force is not required.

Electrical Requirements

The Tork-Trak TM controller requires a power source of 230 Volts AC, single phase or 230 Volts AC, three phase, 60/50 Hz, with a ground wire, capable of supplying 15 through 20 amperes depending upon the tool model being controlled. Refer to the following chart for tool model number and power requirements.

Tool Model	Supply Voltage VAC	Peak Supply Current Amps	Average Power KVA
DGD Series 1 Nutrunners	230V 1Ø	8	0.75
DGD Series 2 Nutrunners	230V 1Ø	16	0.75
DGD Series 3 Nutrunners	230V 3Ø	30	1.0
DGD Series 4 Nutrunners	230V 3Ø	48	1.0
EMT 80 Nutrunners	230V 1Ø	10	0.75
EMT 200 Nutrunners	230V 1Ø	20	1.0
EMT 400 Nutrunners	230V 3Ø	30	1.0
EMT 600 Nutrunners	230V 3Ø	40	1.0
EMT 800 Nutrunners	230V 3Ø	40	1.25
EMT 1200 Nutrunners	230V 3Ø	55	1.25
Cleco Model 17 Series Handtools	230V 1Ø	8	.75
Cleco Model 47 Series Handtools	230V 1Ø	16	1.0
Cleco Model 67 Series Handtools	230V 1Ø	25	1.0

Figure 1-2 Controller AC Input Power Requirements

Power Drop Wiring

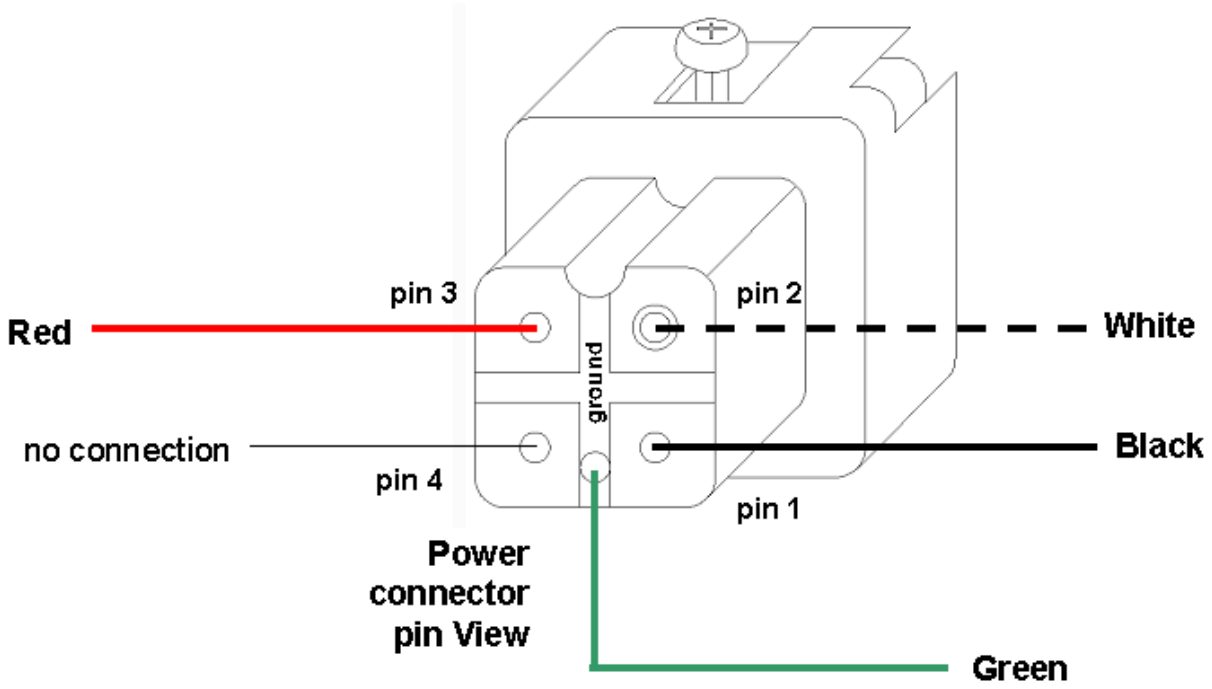
It is recommended that the fuse selection and conductor AWG gage be based on Average Supply Current shown in the Average Power KVA column in Figure 1-2. Note that while most of the tools are single phase, six of the tools are three phase. If under-sized conductors are used, the delivered torque of the fastening nutrunner will be below the catalog torque rating. It is recommended that Slow-Blow fuse protection be considered to prevent nuisance trips from peak current requirements.

The Tork-Trak TM Controller is shipped with a power drop cable, Cooper Power Tools Part Number 576166. This same cable can be used for single phase or three phase operation. One end of the power cable is terminated with a 5 pin connector which plugs into the power connector bulkhead on the controller enclosure, bottom left rear. The other end of the cable is un-terminated with a 4 conductor pigtail. The following chart shows the wiring colors assigned for single and three phase operation:

Supply Voltage	Function	Cable 576166 Wire Color
Single Phase 230 VAC	230 VAC single phase	Black
	230VAC single phase	Red
	Ground	Green
Three Phase 230 VAC	230 VAC 3 phase	Black
	230 VAC 3 phase	Red
	230 VAC 3 phase	White
	Ground	Green

Power Connector Wiring

The following illustration shows the pin view of the power cable connector.
In general, wire Black, Red for single phase controllers and Black, Red, White for three phase controllers.



Power Cable Connector Pin View Wiring

RFI Filtering and Surge Suppression

The central component of the Tork-Trak Controller is a Celeron CPU which under certain plant conditions could be susceptible to high levels of Radio Frequency Interference (RFI) or large transient voltage spikes, Electro- Magnetic Interference (EMI). Both RFI and transient noise are usually transmitted through the plant AC voltage distribution system. A combination transient suppression and RFI suppression module is installed in the Tork-Trak TM enclosure which will help protect the operation of the controller under these types of AC generated noise.

SECTION 2

Overview of the Tork-Trak TM Controller

This section is an overview of the hardware components which make up the Tork-Trak TM controller. Each of these major components will be discussed in detail on a functional basis. Some of the components under discussion are Optional, and may or may not be installed in your controller. The major components are:

Tork-Trak TM Controller Major Hardware Components	
•	T3M Enclosure Top Assembly
•	CPU and Display Sub-Assembly
•	Connector Plate Sub-Assembly
•	Sub-Plate Sub Assembly
•	TM Servo Module
•	Keyboard

T3M Enclosure Top Assembly

Power Disconnect

The power disconnect turns the AC drop (single or three phase) ON or OFF. The disconnect switch may be padlocked in the OFF position. The AC drop enters the enclosure through a connector mounted on the bottom surface of the enclosure in the rear left corner.

LCD Display

The LCD Display is a high resolution color monitor with an 8.4 inch XGA TFT Digital LCD Display Module, and 1024 x 768 pixels resolution.

TM Servo Module

There are three different TM Servo Modules available which supply different values of peak current. The servos are matched to different tools to deliver specific ranges of rated torque. The servo also evaluates outputs from the torque transducer and resolver. All fastening strategies (sequences) are resident within the Servo Module firmware.

TMH Servo
Used with all Cleco hand tools and Rotor Tools. Rated at 40 amps peak current.

TM12 Servo
Used with all Series 1 and 2 DGD fixtured spindles. Also used with EMT 80 and EMT 200 fixtured tools. Servo rated at 22 amps peak current.

TM34 Servo
Used with all Series 3 and 4 DGD fixtured spindles. Also used with EMT 400, EMT 600 and EMT 800 fixtured tools. Rated at 66 amps peak current.

CPU and Display Sub-Assembly

The CPU and Display Sub Assembly contains the following major components:

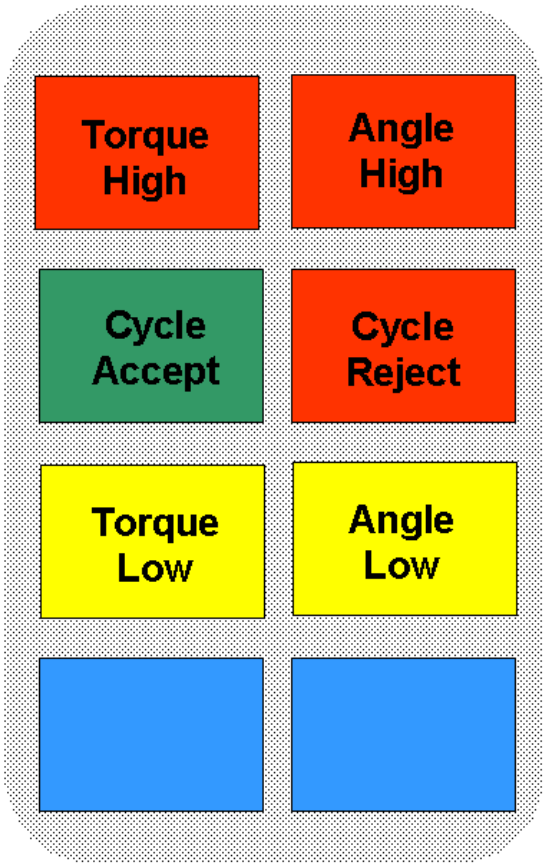
- LCD Display
- Indicator Lights and Overlay Lens
- Hard Drive
- CPU / Mother Board (PC-104 Bus)
- PC-104 I/O Board
- PC-104 FieldBus Board
  - DeviceNet
  - Profibus
- PC-104 ArcNet Board
- Indicator Light Board Assembly
- Private I/O Interface Board Assembly
- Public I/O Interface Board Assembly

Tork-Trak TM Controller PC-104 Technology
I/O
FieldBus
Power Supply
Servo Module
ArcNet
CPU
Tork-Trak TM
Hard Drive
Keyboard / Touch Pad

CPU

The CPU and Mother Board is an extremely compact, low power design supporting the PC-104 bus with a wide operating temperature range 0 to 60 degrees C.. The CPU is a low voltage Celeron with a clock speed of 650 MHz. The memory is 256 MB SDRAM. The MotherBorad supports RS-232 serial, USB 1.1, Ethernet 10/100 and an EIDE Hard Drive port.
The operating system is Microsoft Windows 2000 Professional.
The fastening application software is Cooper Automated Systems TM Multi-Trak, the same software used in the Cooper Power Tools larger 32 spindle panels.

Indicator Lights



Indicator Light Definitions

TORQUE HIGH (RED)	Indicates that the last fastening sequence has exceeded the acceptable final high torque set point.
TORQUE LOW (YELLOW)	Indicates that the last fastening sequence is below the acceptable final low torque set point.
CYCLE REJECT (RED)	Indicates that one or more characteristics of the last fastening cycle is unacceptable.
CYCLE ACCEPT (GREEN)	Indicates that the last fastening sequence has fallen within the acceptable range of the torque and angle set points
FINAL ANGLE HIGH (RED)	Indicates that the last fastening sequence has exceeded the acceptable final angle high set point.
FINAL ANGLE LOW (YELLOW)	Indicates that the last fastening sequence is below the acceptable final angle low set point.
UNMARKED (BLUE)	Indicator can be mapped to any programmed available output by the User.
UNMARKED (BLUE)	Indicator can be mapped to any programmed available output by the User.

Hard Drive

The hard drive is a 40 Gb Hard Drive, Laptop Notebook style. This style of hard drive is very rugged with high reliability and low susceptance to shock and vibration. The Hard Drive stores the TM Multi-Trak application software, the operating system and all database fields which includes rundown data and fastening setup parameters.

ArcNet Coupler Board

The ArcNet coupler board is a PC-104 bus board which plugs into the CPU Mother Board. The ArcNet board communicates information and data between the Mother Board CPU and the TM Servo Module.

Input / Output Board

The I/O board is a PC-104 board which supporting 8 Inputs and 8 Outputs. The Inpits are opto coupled and the Outputs are relay contacts. The Inputs are bi-polar which support active high or active low inputs, sink or source. The I/O board suports inputs and outputs to both the Public I/O and the Private I/O external enclosure connectors.

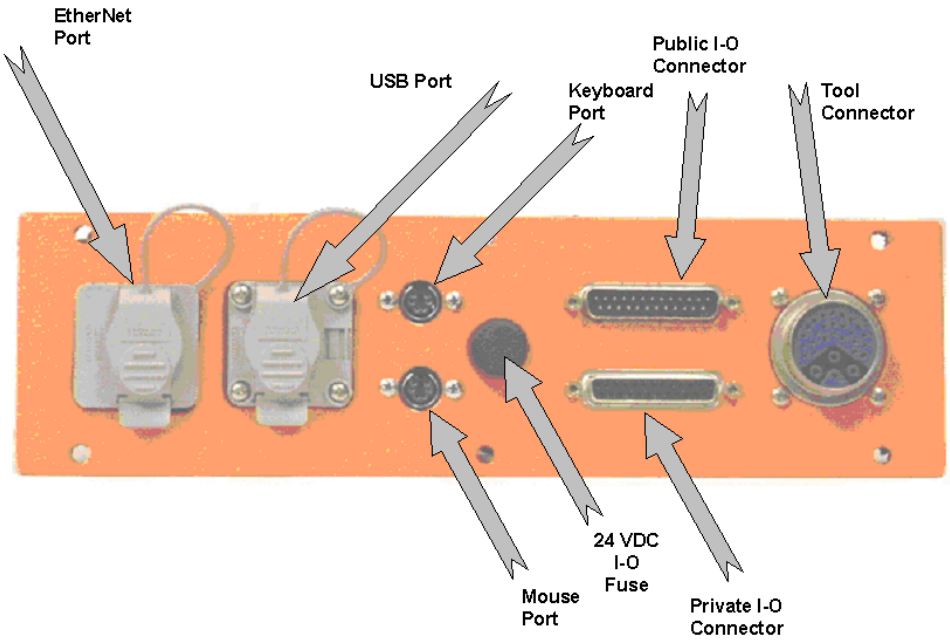
FieldBus (Option)
DeviceNet Board

The DeviceNet board is a slave to the plant public, virtual fieldbus. The DeviceNet board sends or receives virtual discrete I/O signals between the Tork-Trak TM controller and the plant PLC head end. Devicenet software drivers are installed as part of the FieldBus DeviceNet option.
The DeviceNet plant cable drop enters the enclosure through a connector mounted on the bottom surface of the enclosure in the front right corner.

Power Supply

The power supply is located in the upper right section of the enclosure, mounted to the subplate and generates plus & minus 5 VDC, and plus & minus 12 VDC. The power supply is common to the PC/104 CPU, Hard Drive and all PC-104 Boards.

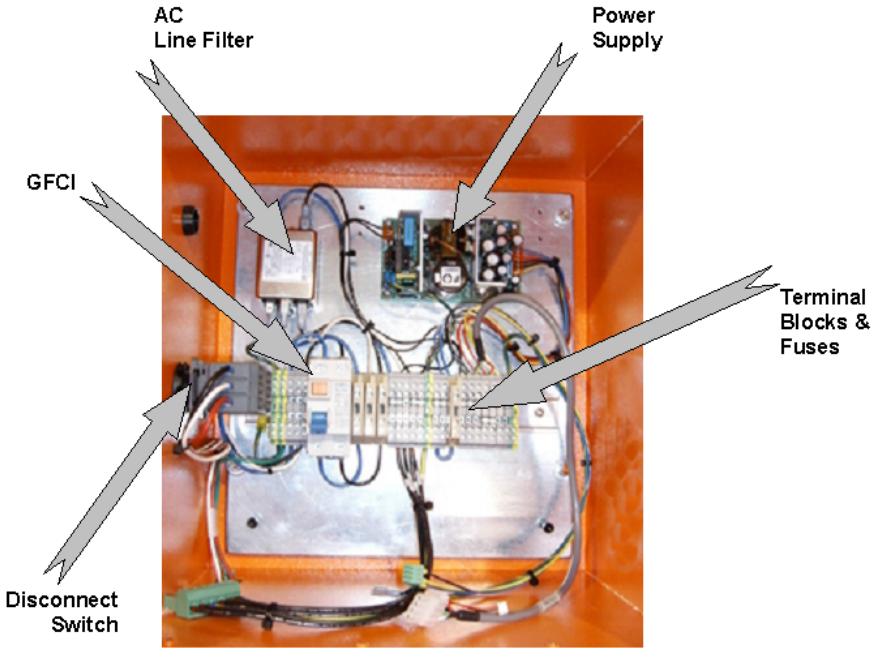
Connector Plate Sub Assembly



The Connector Plate Sub Assembly is located on the bottom front of the Tork-Trak TM enclosure. It provides eight connectors supporting the following functions:

- EtherNet Port
- USB Port
- Keyboard Port
- Mouse port
- 24 VDC I / O Fuse
- Public I / O Connector
- Private I / O Connector
- Tool Connector (fixtured tool connector or hand tool connector)

Sub Plate Sub-Assembly



The Sub Plate Sub Assembly is located on the rear vertical surface of the Tork-Trak TM enclosure. It supports the following functions:

- Terminal Blocks
- Fuses
- GFCI (Ground Fault Circuit Interruptor) 1 or 3 phase
- Power Supply, 24 VDC, 5 VDC, 12 VDC
- AC Line Filter
- AC Disconnect Switch

TM Servo Module

There are three different TM Servo Modules available which supply different values of peak current. The servos are matched to different tools to deliver specific ranges of rated torque. The servo also evaluates outputs from the torque transducer and resolver. All fastening strategies (sequences) are resident within the Servo Module firmware.

TMH Servo
Used with all Cleco hand tools and Rotor Tools. Rated at 40 amps peak current.

TM12 Servo
Used with all Series 1 and 2 DGD fixtured spindles. Also used with EMT 80 and EMT 200 fixtured tools. Servo rated at 22 amps peak current.

TM34 Servo
Used with all Series 3 and 4 DGD fixtured spindles. Also used with EMT 400, EMT 600 and EMT 800 fixtured tools. Rated at 66 amps peak current.

Keyboard and Mouse

The Keyboard is full function, 88 keys, and mouse (trackball + 2 keys). (Upper right corner for the trackball and upper left corner for the mouse function keys)
The end of the keyboard cable splits to two mini-DIn 6 pin connectors. One is for the keyboard function and the other is for the mouse function. Both connectors plug into the external connector plate at the bottom of the enclosure. The connector closest to the front connects the keyboard and the connector closest to the rear connects the mouse.

SECTION 6

Fastening Strategies (Sequences)

Overview

There are two dynamic measurements which occur when fastening joints using electric nut runners. The two measurements are Torque and Angle. Torque is the measurement of rotational force, and Angle is the measurement of the square drive socket rotation angle in degrees measured after reaching a programmed level of torque. Torque is measured in foot pounds or Newton Meters and Angle is measured in degrees.

In establishing a fastening strategy for tightening a threaded joint, either Torque or Angle are chosen as the control function. A strategy can control to a specific Target Torque value and also monitor the angle, or a strategy can control to a specific Target Angle and monitor the resulting torque. Using Torque and Angle as control or monitoring parameters can create a wide variety of specialized Fastening Strategies.

In this Section. the terms Fastening Strategy or Fastening Sequence are used interchangeably.

The Fastening Sequences discussed on the following pages are included in the TM Multi-Trak Fastening Control Software, and are available to the Tork-Trak TM Controller User.

Sequence 10: Engagement Stage

In the electronic control system the maximum evaluation torque, on time, off time and cycle number of the engagement stages are entered separately for each nutsetter.

A maximum tightening time is entered as the safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The engagement stage facilitates the bit and bolt head having firm contact.

For this purpose the nutsetter is operated in both directions alternately. The engagement stage on time sets the duration of the clockwise and counterclockwise movements of the nutsetter, the engagement stage off time the length of time after each movement. An engagement stage cycle consists of a clockwise movement - stop - counterclockwise movement - stop.

The measuring transducer integrated into the nutsetter measures the torque during rundown.
The value is processed by the control system. The nutsetter is stopped when the evaluation torque is reached or the set number engagement stage cycles has been completed. The last measured torque is processed in the control system. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

The graphics function is not supported in this stage.

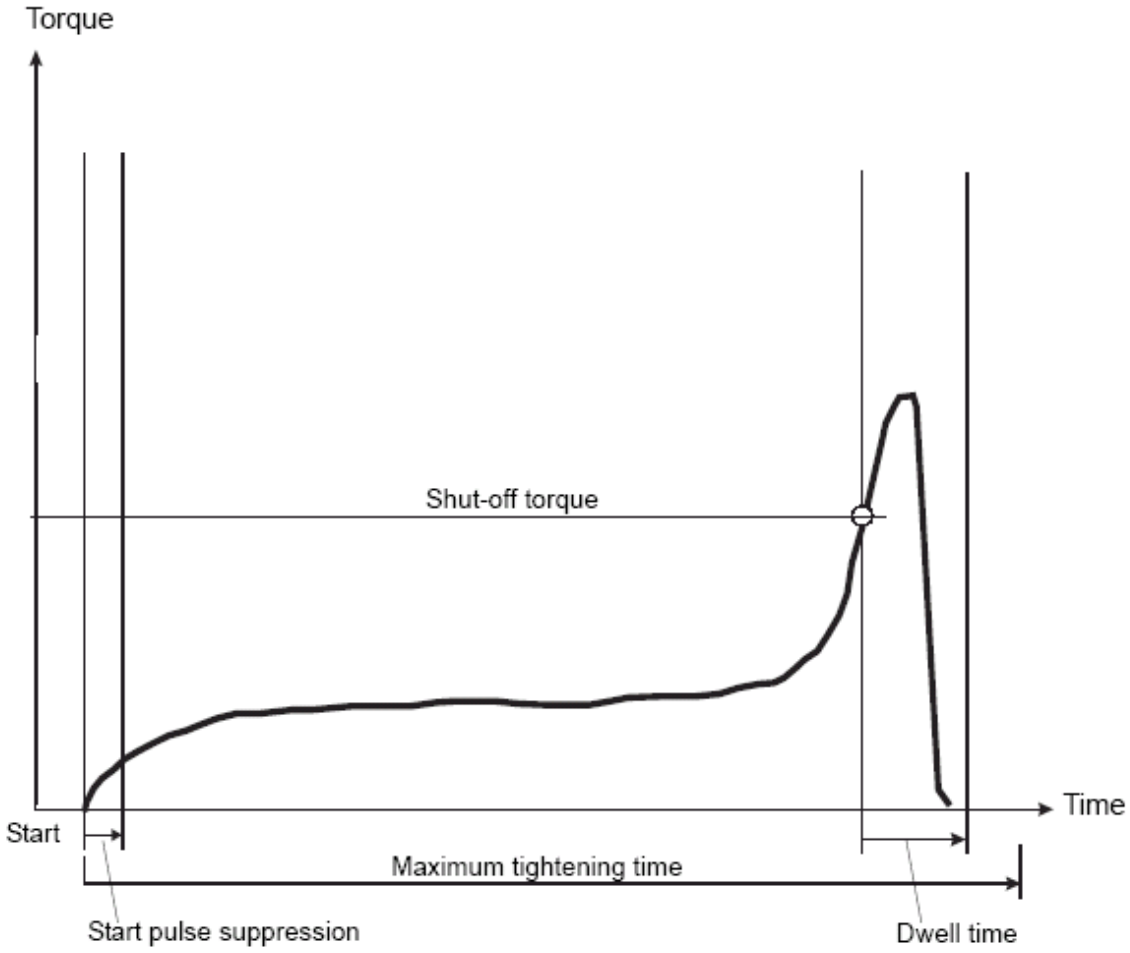
The parameters below are entered in the electronic control system:

Sequence input value: 10

Max. evaluation torque (Nm):	Maximum torque at which the engagement stage is prematurely stopped
Engagement stage on time (ms):	The nutsetter remains switched on throughout this time
Engagement stage off time (ms):	The nutsetter remains switched off throughout this time
Engagement cycles:	Number of engagement stage cycles
Filtering factor:	Filtering factor, number of measured values used for filtering by averaging
Speed (rpm):	Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 11: High Speed Rundown

Shut-off torque controlled fastening up to a contact torque



In the electronic control system the shut-off torque, filtering factor and speed preset are entered separately for each nutsetter. A maximum tightening time is entered as the safety shutdown.
It applies to all nutsetters of a product group (tightening process) in this stage.
The measuring transducer integrated into the nutsetter measures the torque during tightening rundown. The value is processed by the control system. The nutsetter is stopped when the **"shut-off torque"** search criteria is reached.

The peak torque achieved during the dwell time is then measured and processed in the control system as the bolt tightening torque. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.
When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method is normally used as the fast pretightening stage.
The parameters below are entered in the electronic control system:

Sequence input value: 11

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

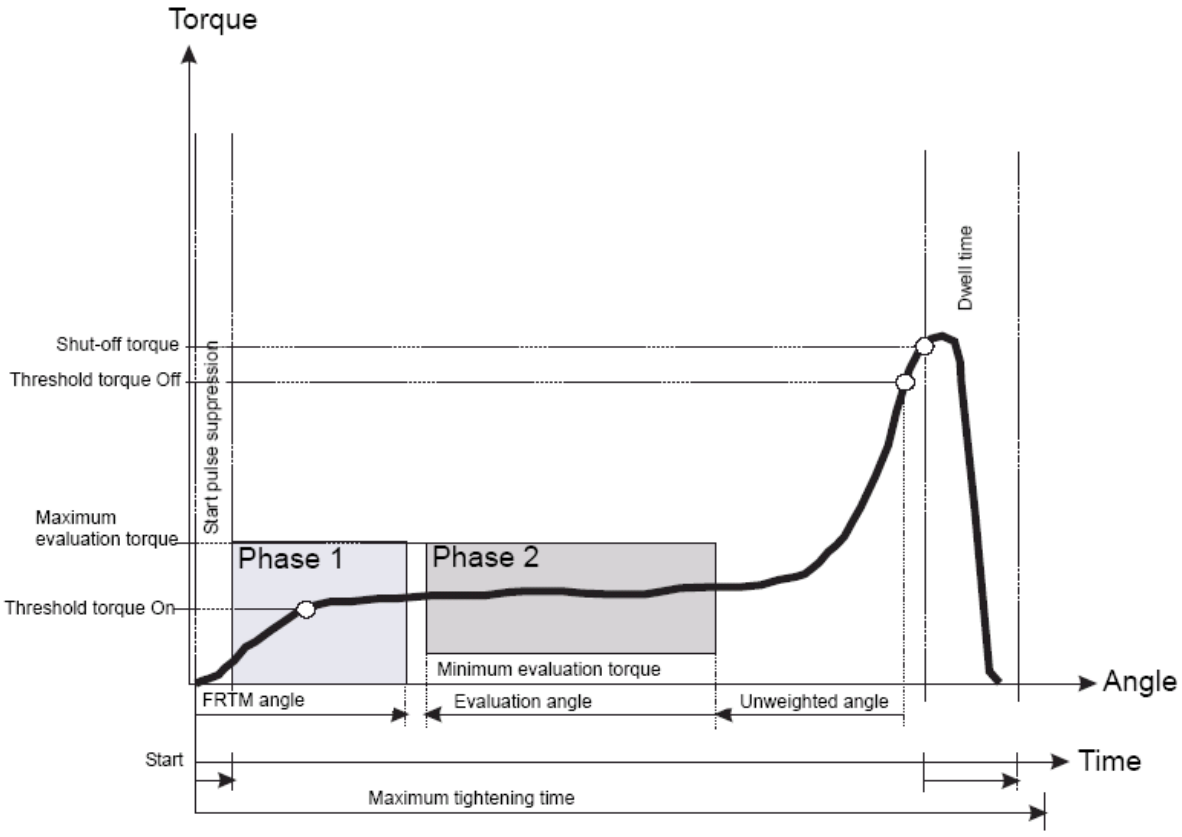
Shut-off torque (Nm): Shut-off torque for the high speed rundown

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 13: Free Rundown Torque Monitoring (FRTM)

Shut-off torque controlled fastening up to a contact torque with partially monitored torque monitoring during tightening and subsequent torque analysis.



In the electronic control system the shut-off torque, threshold torque on, maximum evaluation torque, minimum evaluation torque, threshold torque off, FRTM angle, unweighted angle, evaluation angle, filtering factor and speed preset are entered separately for each nutsetter.

A maximum tightening time is entered as the safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The torque is monitored from the time when the nutsetter starts until the FRTM angle is reached. Rundown is terminated immediately with NOK if the maximum evaluation torque is overstepped in this phase
(phase 1).

Rundown continues without interruption if phase 1 is error-free. The nutsetter is stopped when the **"shut-off torque"** search criteria is reached. The peak torque achieved during the dwell time is then measured and processed in the control system as the bolt tightening torque.

In the evaluation phase (phase 2), which is carried out after rundown, the values recorded between threshold torque on and threshold torque off are evaluated. Torque values within the unweighted angle starting from threshold torque off are not considered. Torque values in the subsequent evaluation angle range are checked for overstep of the maximum evaluation torque and understep of the minimum evaluation torque.

Oversteps and understeps within the evaluation angle, starting from the recorded measuring points, are tolerated. The portion of measuring points that may lay outside of the evaluation torques so as not to trigger a NOK is set with the **above limit** and **below limit** parameters.
A warning is output should this occur.

Any remaining measurements are not considered. The error message "no measurements present" and NOK are output if the sum of the evaluation angle and unweighted angle is greater than number of existing measurements (Error message FSMW "FRTM: Not enough measurement values").

The whole rundown evaluation is processed in the control system. The control system can display the values as text or in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

When the spindle trigger torque is reached, and at the latest when a spindle reaches threshold torque on, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

This tightening method is normally used as the fast pretightening stage with checked tightening monitoring and subsequent evaluation.

The parameters below are entered in the electronic control system:

Sequence input value: 13

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Shut-off torque (Nm): Shut-off torque for this high speed rundown

Threshold torque On (Nm): Threshold torque on, beginning of the monitored range (beginning of angle counting)

Threshold torque Off (Nm): Threshold torque off, end of recording for subsequent evaluation (phase 2)

FRTM angle (deg): FRTM angle, length of the monitored range after the spindle start in phase 1

Evaluation angle (deg): Range evaluated in phase 2

Unweighted angle (deg): Range not evaluated in phase 2

Shut-off torque (Nm): Shut-off torque for the stage

Max. evaluation torque (Nm): Maximum torque in the monitored range, high limit in phases 1 and 2

Min. evaluation torque (Nm): Minimum torque in the monitored range, lower limit in phase 2

Above limit (%): Portion of measurements tolerated that lay over the high limit without triggering NOK (phase 2)

Below limit (%): Portion of measurements tolerated that lay below the low limit without triggering NOK (phase 2)

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Jointing-point detection: Jointing-point detection

Joint-point Detection

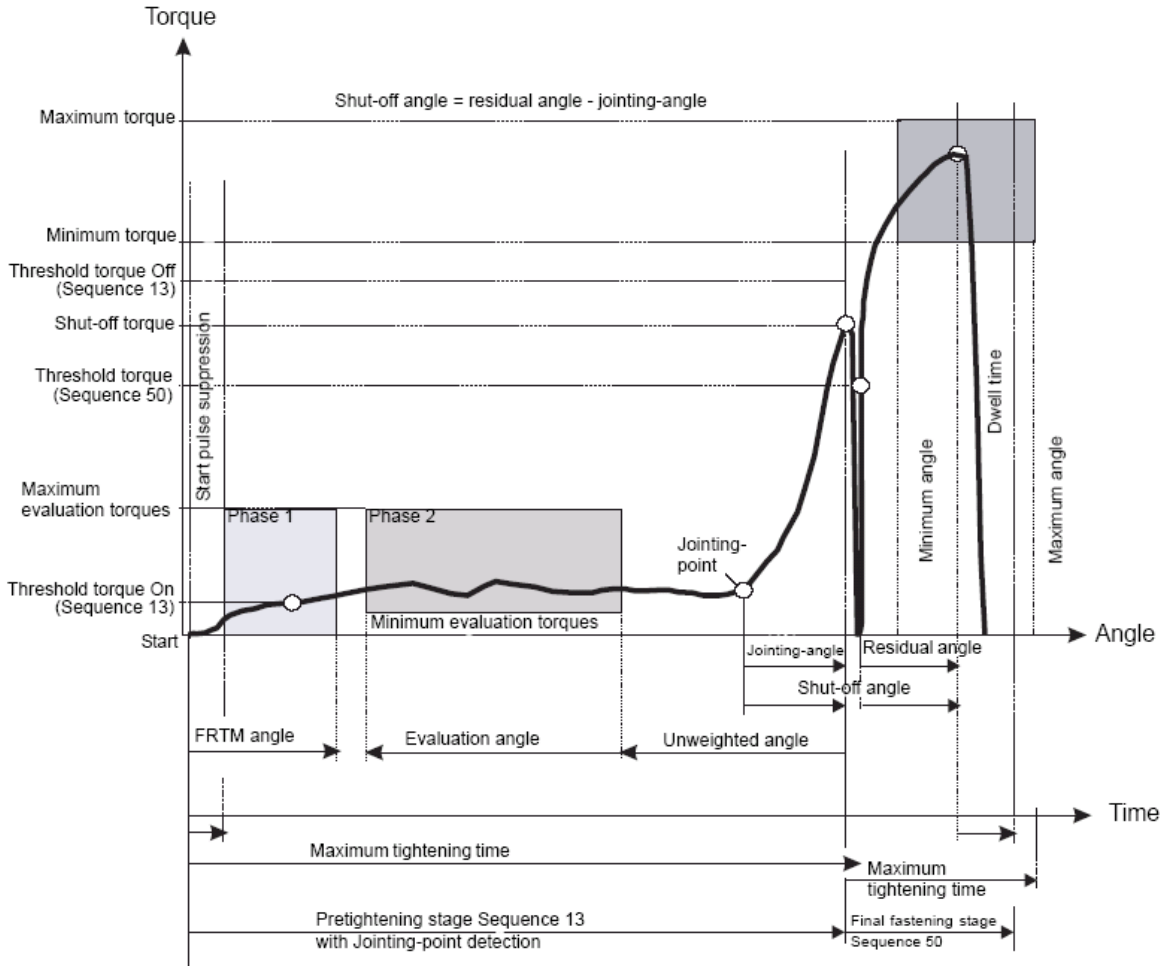
Certain conditions apply that are necessary for exact joint-point detection when this option is activated in free rundown torque monitoring with sequence 13. These are:

- At least 256 torque values must have been measured during free rundown torque monitoring.
- Sequence 50 must be the sequence (final fastening) that directly follows this fastening stage.
- There must have been a high increase in torque at the end of the free rundown torque monitoring.

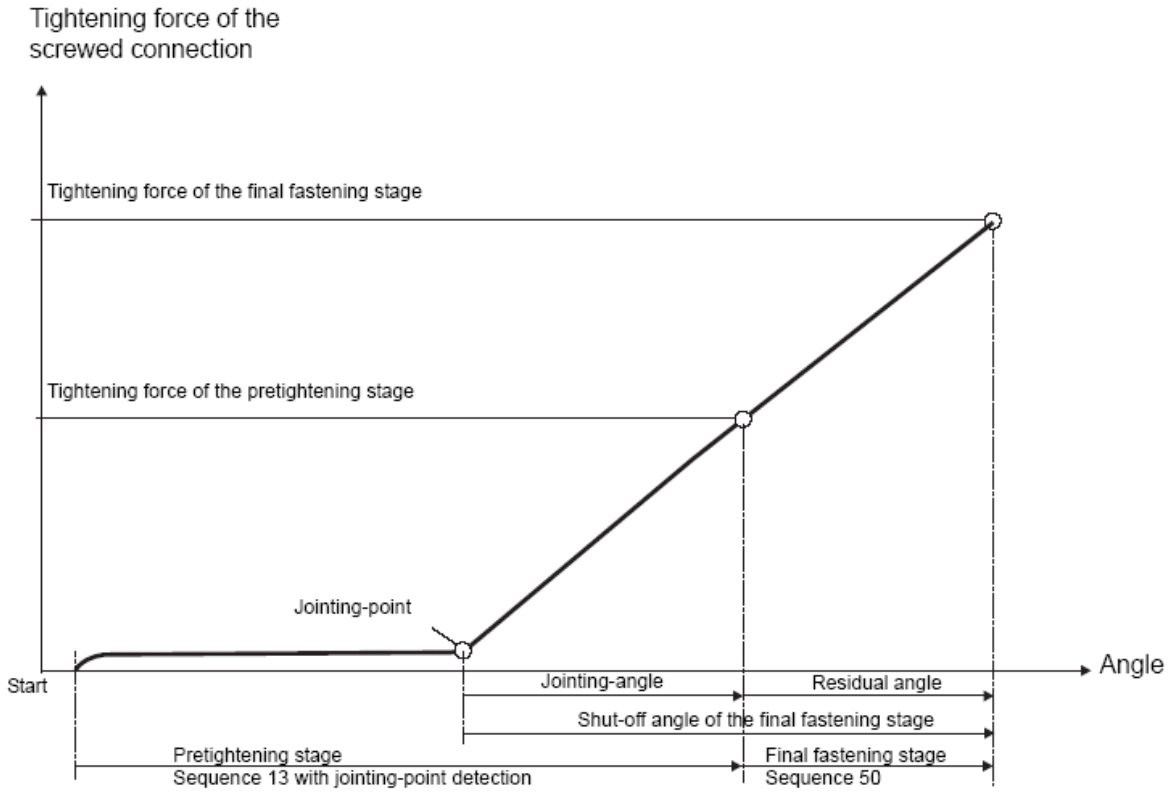
This means that the contact torque (shut-off torque) for the free rundown torque monitoring has to lay significantly above the tightening frictional torque.
A jointing-point is defined as the point at which two or more parts in a severable connection make connection. A strong increase in torque within a few fastening angles is indication that such an event has happened.
The precise jointing-point in this pretightening stage can be determined by reevaluating the recorded torque values and ascertaining the torque increase gradients.
The angle from the jointing-point up to shut-off of the pretightening stage is described as the jointing-angle.
During jointing-angle detection it is obligatory to use a shut-off controlled tightening method with rotation angle and torque monitoring (final fastening stage with sequence 50).
The jointing-angle ascertained in the pretightening stage reduces the shut-off angle for the final fastening stage by the amount of the jointing-angle. This keeps the angle constant from the jointing-point of the pretightening stage up to standstill of the built-in nutsetter in the final fastening stage. In turn, this has the effect that the tightening force of the pretightening stage is also compensated for in the final fastening stage, in order to prevent overstep of the maximum tightening force of the final fastening stage.
Errors within the tightening method with jointing-point detection are evaluated and are processed in the control system together with the bolt tightening values. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

Note:

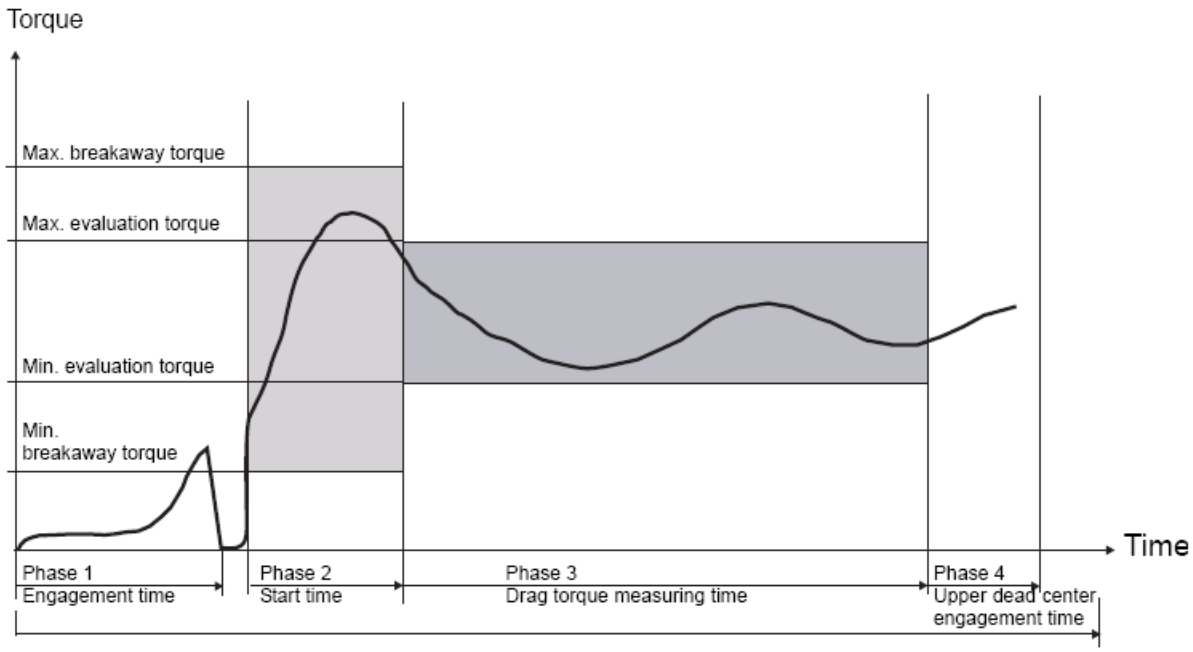
The threshold torque in the final fastening stage (sequence 50) should be parametrized so that it is below the shut-off torque in the pretightening stage (sequence 13) and allows the tightening method to work correctly with jointing-point detection.
Angle counting stops at the pre-tightening stage shut-off point (diagram 13) and only continues when the threshold torque of the end fastening stage is reached (diagram 50) (shut-off angle = joint angle + remaining angle). The parameters for the pre-tightening stage run-on time (diagram 13), the delay time between the stages and the end tightening stage start pulse suppression (diagram 50) must be set to "0" here.
Additionally, the threshold torque off should be selected for the pretightening stage (sequence 13) so that the complete torque rundown is fully recorded in the graphic. This is the only way to guarantee that the tightening force remains reproducibly constant.



In the figure above the process is shown correctly from the standpoint of measuring technology.
The more interesting representation for the user shows the tensioning force of the screwed connection, which is shown as being equivalent to the tightening torque.


Tightening force of the screwed connection
Tightening force of the final fastening stage
Tightening force of the pretightening stage
Jointing-point
Start
Angle
Jointing-angle
Residual angle
Shut-off angle of the final fastening stage
Pretightening stage
Sequence 13 with jointing-point detection
Final fastening stage
Sequence 50

Sequence 15: Frictional torque measurement



Frictional torque measurement is started in the same way as a normal rundown cycle and is carried out fully by the nutsetter control. Frictional torque measurement is divided into four phases, which are called up and run after one another. The functions below are executed in the individual phases:

Phase 1: Engagement

The nutsetter is started clockwise and turns until an initiator ("FindINI") reports that the engaging device (normally a bit) has engaged. The measuring transducer integrated into the nutsetter measures the torque and rotation angle during the sequence. The values are processed by the control system. For safety reasons, whenever the "Max. breakaway torque" oversteps the torque in any phase the nutsetter is stopped and evaluated as NOK.

Phase 2: Start Time

Slide out of interference range (SIS) must be set before the nutsetter is started clockwise. The breakaway torque is monitored in this phase. It must lay within the "Min. breakaway torque" and "Max. breakaway torque" limits. If this is the case the sequence continues into phase 3, if this is not the case there is an immediate nutsetter stop.

Phase 3: Frictional Torque Measuring Time

During the frictional torque measuring time the torque is monitored for overstep and understep of the "Max. evaluation torque" and "Min. evaluation torque" and the maximum and minimum frictional torques are registered. After the measuring time has been completed the frictional torque measurement is ended and transition into phase 4 is continuous.

Phase 4: "Engage Upper Dead Center" (move to a defined end position)

During phase 4 the spindle is rotated until an initiator signals it has reached the "upper dead center position" (upper dead center position DTM, upper dead center "OTINI"). The whole measuring cycle evaluation is processed in the control system. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

The parameters below are entered in the electronic control system:

Sequence input value:	15
Max. breakaway torque (Nm):	Safety shut-down torque
Min. breakaway torque (Nm):	Low limit of the breakaway torque for evaluation in the start time
Max. evaluation torque (Nm):	High evaluation torque during the measuring time
Min. evaluation torque (Nm):	Low evaluation torque during the measuring time
Start time (ms)	Time to overcome the breakaway and to monitor the backoff torque, determines the length of phase 2

Measuring time (ms):	Time in which the frictional torque is checked, determines the length of phase 3
Filtering factor:	Filtering factor, number of measured values used for filtering by averaging
Speed (rpm):	Preset speed; within the maximum speed range set in the spindle constants

Sequence 16 Event-dependent turning

Positioning Stage

The purpose of this sequence is to stop the built-in nutsetter after a specified position (initiator position, "FindINI") after a defined angle shut-off value in order, for instance, to obtain an exact ("upper dead center") position for a machining workpiece.

When the input sequence begins in the tightening process the spindle starts to fasten or turn.

Angle counting begins after the initiator position has been reached. The built-in nutsetter stops when the entered shut-off angle is reached. The angle shut-off values reached are processed in the OK/NOK evaluation. There is no provision to evaluate the reached torque value.

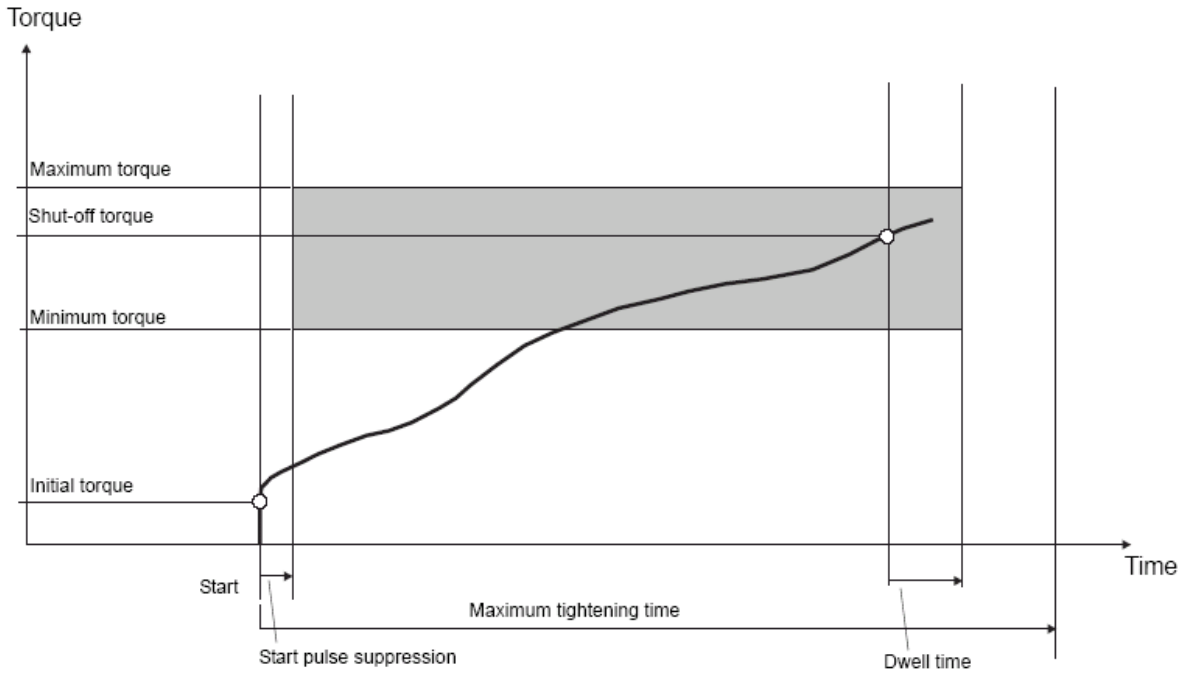
If the maximum torque is reached during fastening, the spindle shuts off and is given a NOK evaluation.

The graphics function is not supported in this stage.

The parameters below are entered in the electronic control system:

Sequence input value:	16
Filtering factor (Nm):	Filtering factor, number of measured values used for filtering by averaging
Shut-off angle (Nm):	Shut-off angle for the stage
Maximum angle (deg):	Maximum angle, high limit for angle reached and shutoff value
Minimum angle (deg)	Minimum angle, low limit of angle reached
Maximum torque (Nm)	Maximum torque, high limit of torque reached and shut-off value
Speed (rpm):	Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 20: Shut-off Torque Controlled Fastening with Torque Monitoring



In the electronic control system the shut-off torque, maximum torque, the minimum torque, the filtering factor and the speed, are entered separately for each nutsetter.
A maximum tightening time is entered as the safety shut-down.
It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque during tightening rundown. The value is processed by the control system. The nutsetter is stopped when the "shut-off torque" search criteria is reached. The peak torque achieved during the dwell time is then measured and processed in the control system as the bolt tightening torque together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value: 20

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

Shut-off torque (Nm): Shut-off torque for the stage

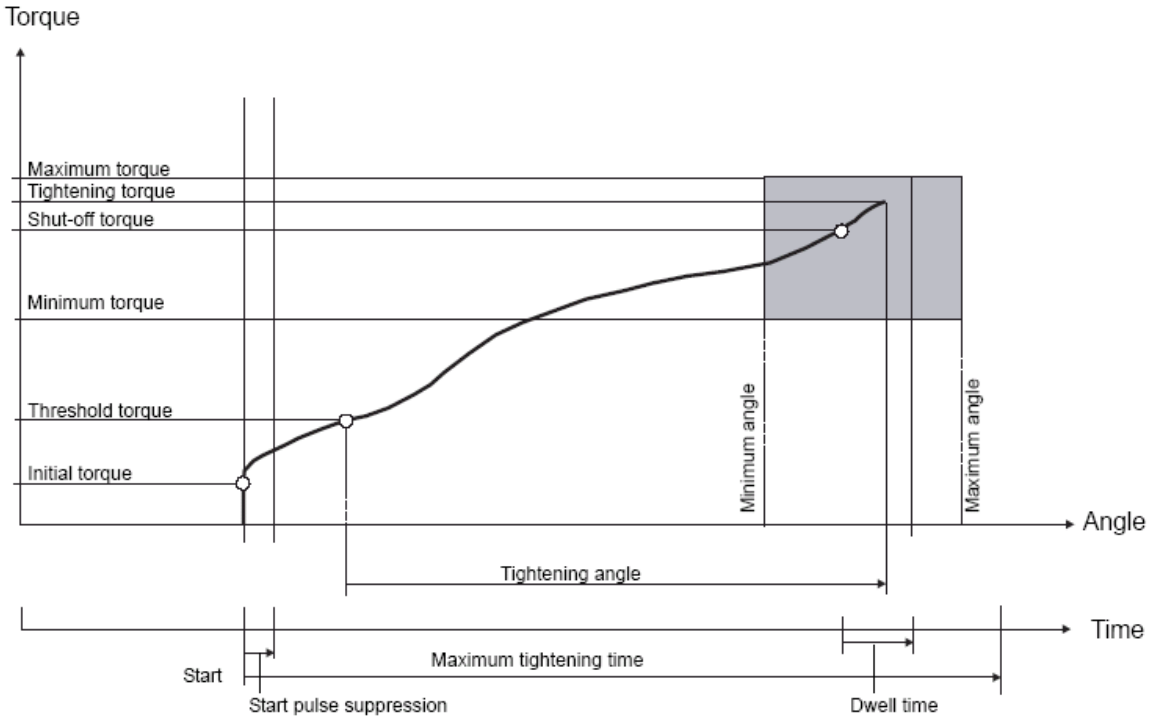
Maximum torque (Nm): Maximum torque, high limit of torque reached

Minimum torque (Nm): Minimum torque, low limit of torque reached

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 30: Shut-off Torque Controlled Fastening with Torque Monitoring and Angle Monitoring



In the electronic control system the **shut-off torque**, maximum torque, minimum torque, threshold torque, maximum angle, minimum angle, the filtering factor and the speed are entered separately for each nutsetter.
The maximum angle is also used as a safety shut-down.
A maximum tightening time is entered as an additional safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.
The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The angles are counted once the threshold torque is reached. The nutsetter is stopped when the **"shut-off torque"** search criteria is reached. The dwell angle and peak torque achieved during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.
When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

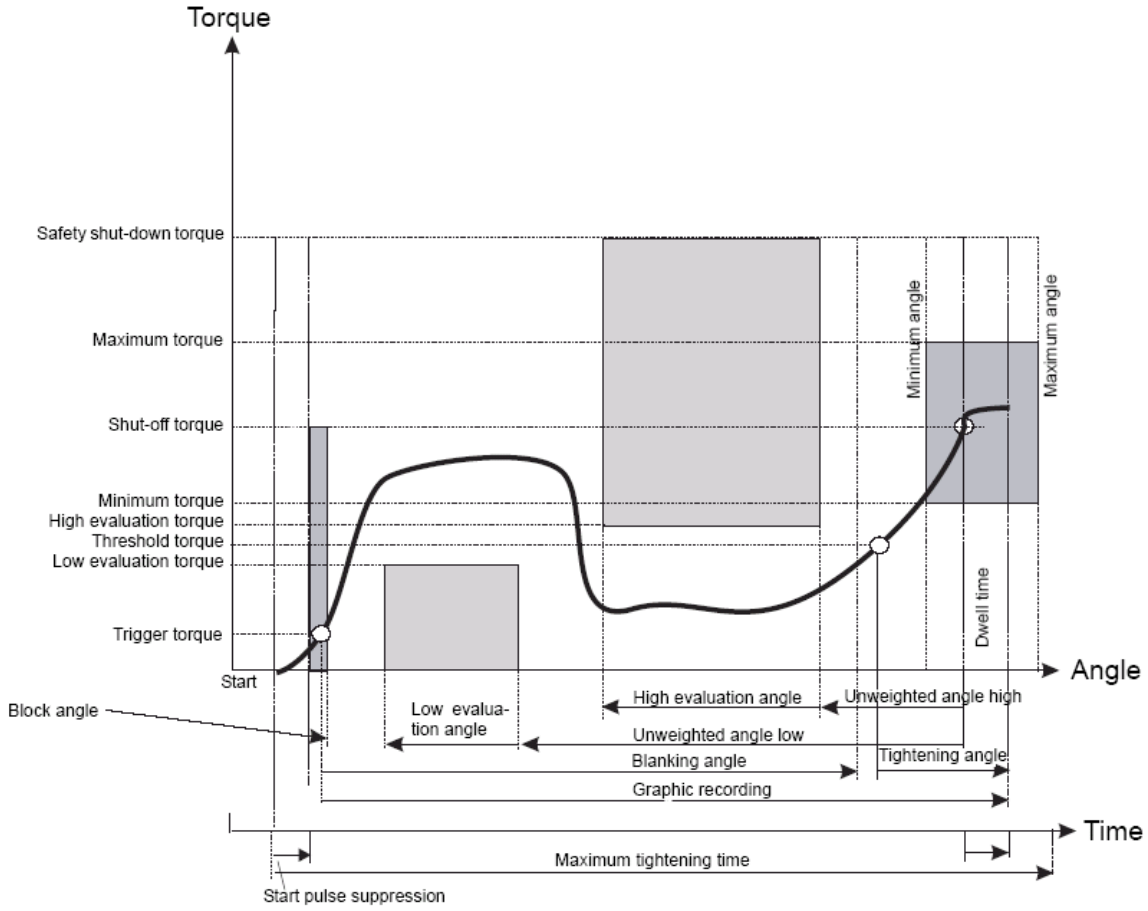
This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value:	30
Trigger torque (Nm):	Trigger torque, beginning of measurement recording for the graphic display
Threshold torque (Nm):	Threshold torque, beginning of angle counting
Shut-off torque (Nm):	Shut-off torque for the stage
Maximum torque (Nm):	Maximum torque, high limit of torque reached
Minimum torque (Nm):	Minimum torque, low limit of torque reached
Maximum angle (deg):	Maximum angle, high limit for angle reached and safety shut-off value
Minimum angle (deg):	Minimum angle, low limit of angle reached
Filtering factor:	Filtering factor, number of measured values used for filtering by averaging
Speed (rpm):	Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 31: Shut-off Torque Controlled Fastening with Torque Monitoring and Angle Monitoring

Sequence 31 is a torque-controlled sequence, which allows the rundown to be evaluated after the shut-off torque has been reached by means of reverse analysis over two monitoring ranges.



The torque curve can be reverse analyzed after rundown is complete. This reverse analysis
starts at the shut-off point (the dwell time is not considered) and is achieved using two separate
angle ranges.

These angle ranges can be specified separately from one another by setting parameters for the
end of the range (= unweighted angle high or low) and the length of the range (= evaluation
angle high or low). The two evaluation angles can be in any order and also fully or partially overlap.

The high evaluation angle of the torque curve is checked for overstep of the high evaluation torque and the low evaluation angle of the torque curve is checked for understep of the low evaluation torque. The tightening process is assessed as being NOK if there were oversteps and/or understeps.

The maximum torque is measured within the high evaluation angle, and the lowest torque value within the low evaluation angle and statistical evaluation is carried out. The evaluation torques can be deactivated by setting the corresponding evaluation angle to zero.

In the **block angle** range, which begins directly after the start pulse suppression, the torque must not exceed the shut-off torque as this will stop the drive. This serves to detect rundowns that are carried out on a tightened bolt. The block angle can be deactivated by setting it to zero.

The torque curve is recorded for the graphic starting from the **trigger torque** (1 torque value per angle degree). These values are also the basis for the reverse analysis. Therefore, the trigger torque must be parametrized so that the torque curve relevant for reverse analysis is always recorded!

An error message with NOK evaluation is generated if there are insufficient torque values for reverse analysis. The torque curve can be output as a graphic.

Parameters can be set for a **blanking angle** that starts when trigger torque is reached. During the blanking angle, detection of the threshold torque and shut-off torque is deactivated and is only reactivated after the blanking angle has finished.
It is permissible for the torque to be higher than the shut-off torque in the blanking angle, but the safety shut-down torque must not be exceeded. The drive is stopped when the safety shut-down torque is exceeded, which applies in the sequence from the end of the impulse suppression time up to the shut-off point. An error message with NOK evaluation is generated. The blanking angle can be deactivated by setting it to zero.

If the block angle and blanking angle overlap, the shut-off torque is considered to be a termination criteria until the end of the block angle.

Angle counting starts when the **threshold torque** is reached if detection of the threshold torque has not been deactivated by the block angle or blanking angle.
Note: If the threshold torque = trigger torque, then angle counting starts when the threshold torque is reached and continues in the blanking angle.

Angle measurement and possibly also redundancy monitoring starts when the drive starts.

After the shut-off torque has caused a shut-down, the torque and/or the corresponding angle are compared to the minimum/maximum torque and the minimum/ maximum angle and evaluated accordingly as OK or NOK. Reverse analysis is also carried out.

The maximum angle, safety shut-down torque and maximum tightening time for the stage are used as a safety shut-down.

Description of parameters

Sequence input value: 31

Filtering factor: Number of measured torque values used for averaging

Trigger torque (Nm): Beginning of storing torque values for the graphic display, reverse analysis and blanking angle

Threshold torque (Nm): Beginning of angle counting; valid outside the blanking angle and block angle

Shut-off torque (Nm): Torque at which the drive is stopped and the dwell time begins; valid outside the blanking angle

Safety shut-down torque (Nm): Monitoring torque valid after start pulse suppression has finished and during the rundown, and the value at which the drive is stopped when it is exceeded

Block angle (deg): Angle, beginning at the end of start pulse suppression, in which the torque must be lower than the shut-off torque

Blanking angle (deg): Angle range starting at the trigger torque, in which the shut-off torque and threshold torque are invalid

Unweighted angle high (deg): End point of the evaluation angle high, related to the shut-off point (reverse)

Evaluation angle high (deg): Length of the monitored range for overstep of the high evaluation torque

High evaluation torque (Nm): High torque limit in the evaluation angle high that must not be exceeded in reverse analysis

Unweighted angle low (deg): End point of the evaluation angle low, related to the shut-off point (reverse)

Evaluation angle low (deg): Length of the monitored range for understep of the low evaluation torque

Low evaluation torque (Nm): Low torque limit in the evaluation angle low that must not be understepped in reverse analysis

Maximum torque (Nm): High limit of torque reached

Minimum torque (Nm): Low limit of torque reached

Maximum angle (deg): High limit for angle reached and safety shut-off value

Minimum angle (deg): Low limit of angle reached

Speed 1 (rpm): Preset speed; maximum speed specified in the range for spindle constants, valid from the beginning of the sequence up to the threshold torque

Speed 2 (rpm): Speed when the shut-off torque is reached. Must be lower than speed 1.
Cutoff is deactivated when speed 2 = 0 or speed 2 >= speed 1.

Parameter	Start	End	Evaluation sequence	Suppressed in
Threshold torque	*After start pulse suppression*	*Shut-off point reached*	1	*Block angle, blanking angle*
Safety torque shut-down			2	---
Shut-off torque			3	Block angle, blanking angle
Trigger torque			4	---

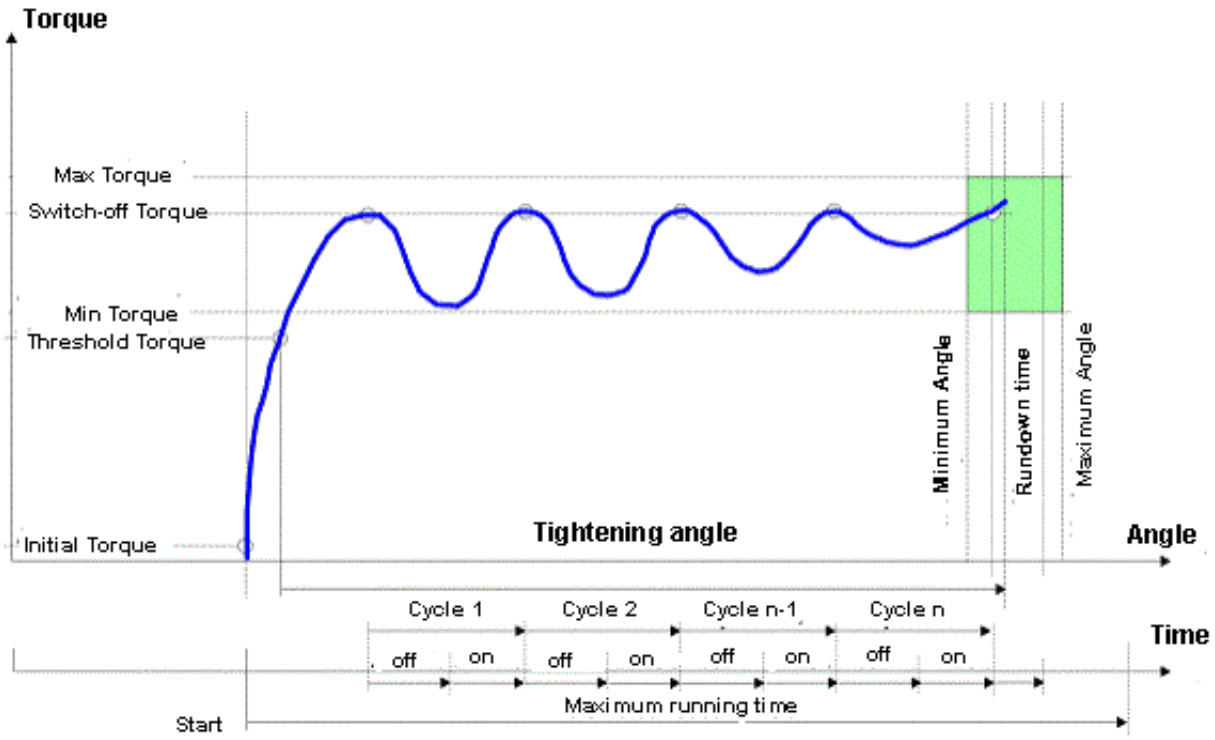
When the values are equal the sequence for evaluation causes a higher priority for evaluation, for instance, of the threshold torque before the trigger torque, i.e. the threshold torque and thus angle counting are activated when the trigger torque and threshold torque have the same numeric values, even if a blanking angle is defined.

Parameter	Start	End	Deactivation
Blanking angle	Trigger torque	After blanking angle degree	Blanking angle = 0
Block angle	After start pulse suppression	After block angle degree	Block angle = 0
Speed 1	At spindle start	1) Shut-off point when speed 2 = 0 2) Threshold torque when speed 2 > 0	---
Speed 2	From threshold torque	Shut-off point	Speed 2 = 0 or Speed 2 ≥ speed 1

Parameters that are analyzed in reverse, i.e. starting from the shut-off point:

Parameter	Start	End	Deactivation
High evaluation angle	Shut-off point minus upper unweighted angle	Shut-off point minus upper unweighted angle minus high evaluation angle	High evaluation angle = 0
Upper unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
Upper evaluation torque	*Valid in the high evaluation angle*		High evaluation angle = 0
Low evaluation angle	Shut-off point minus lower unweighted angle	Shut-off point minus lower unweighted angle minus low evaluation angle	Low evaluation angle = 0
Lower unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
Low evaluation torque	*Valid in the low evaluation angle*		Low evaluation angle = 0

Sequence 33 Switch-off Torque Controlled Tightening Procedure with Torque Maintenance and Automatic Retightening



This tightening procedure must be preceded by a pre-clamping Sequence. Sequences 30, 31, 50 51, 63, 73, 75, and 80 show the clamping procedures.

The electronics for each spindle have separate parameters for number of repetitions, on-time, off-time, the switch-off torque, maximum moment, minimum moment, maximum angle, minimum angle, damping factor, trigger moment, the threshold torque and the specified RPM's.

The maximum angle is used as a safety switch-off.

Maximum running time is also specified as an additional safety switch-off.
This affects all spindle drivers of a product group (driving process) in this stage.

The torques and angles of rotation during an operation are measured and processed in a sensing element built into the drivers.

The angles are measured once the threshold moment has been achieved. The driver is operated alternately between rotary motion and maintaining the desired torque. Upon reaching **"Switch-off Torque".** the driver is stopped and the switch-off torque is maintained, preventing mechanical relief of the spindle. During the off-time, the mechanical settling can take place. When the off-time has expired, or if the torque falls below the specified minimum, the spindle starts again with the specified RPM. When the on-time has expired, or if **"Switch-off torque"** has been exceeded, the spindle is stopped again and the switch-off moment is maintained. One cycle consists of one on-time and one off-time. The number of cycles equals the number of specified repetitions.

During the run-down time, the caster angle and peak torque are measured. An automatic, slow and controlled relief of the spindle takes place during the specified run-down time, until torque falls below the specified threshold.

The tightening values of the bolt and a reading of the fastened joint are sent to the value analyzer.

This Sequence can display the values in tabular form on the monitor and / or output to a printer, as well as transmit this information to other network clients.

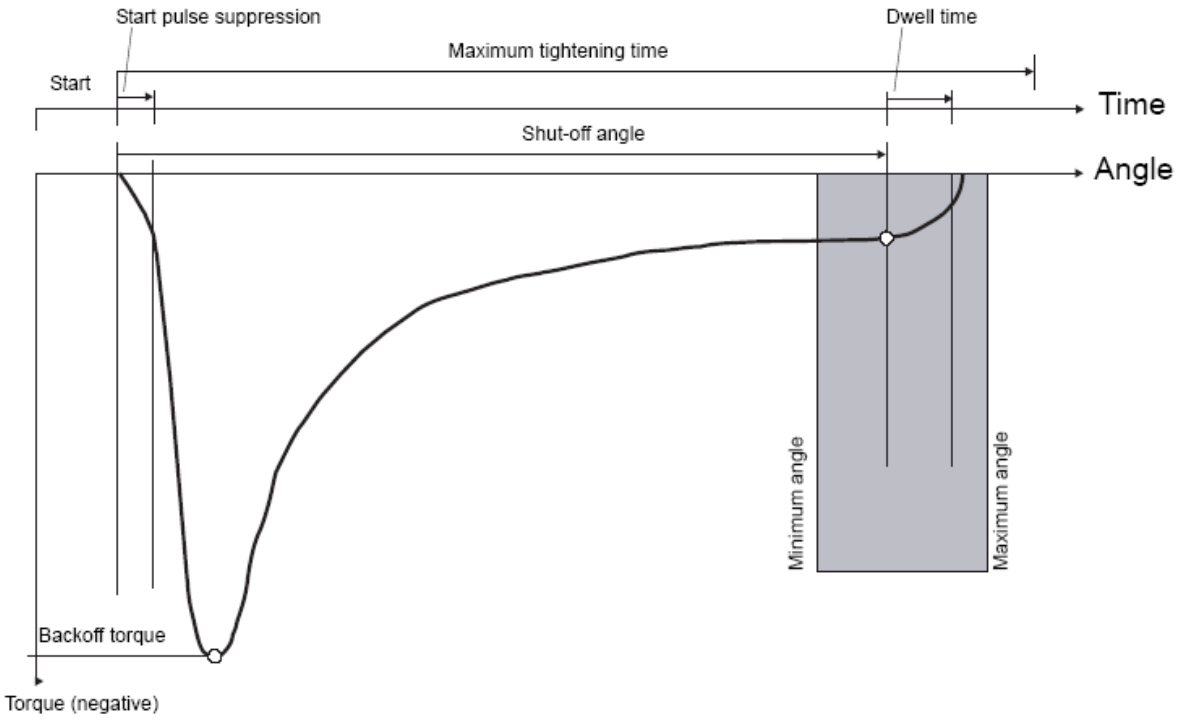
Once a spindle reaches the specified trigger moment, the rotation angle is recorded and can be displayed and evaluated via the graphic function.

The following parameters can be input to the driver electronics:

Diagram input value:	33
Switch-off torque (Nm)	Stage switch-off torque
Maximum torque (Nm):	Maximum torque, upper limit of achieved torque
Minimum torque (Nm)	Minimum torque, lower limit of achieved torque
Maximum angle (grd):	Maximum angle, upper limit of achieved angle and safety switch-off torque
Minimum angle (grd):	Minimum angle, lower limit of achieved angle

Threshold torque (Nm):	Threshold torque, start of angle counter
Threshold moment (Nm)	Trigger moment, start of value recording for graphic display
Number of repetitions:	Number of repetitions of THC on-time and THC off-time
THC on-time (ms):	The spindle remains switch-on for the duration of this period, as long as the switch-off torque has not been achieved
THC off-time (ms):	The spindle remains in hold mode as long as the minimum torque is maintained
Damping factor	Damping factor, number of measured values based on averaging applied to damping
RPM	RPM selection; in the range of specified maximum RPM's in the spindle constants

Sequence 41 Shut-off Angle Controlled Backoff with Backoff Angle Monitoring



In the electronic control system the **shut-off angle**, maximum angle, minimum angle, filtering factor and speed are entered separately for each nutsetter.

A maximum tightening time is entered as the safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the angle during back-off. The value is processed by the control system. Angles are counted from the start.

The nutsetter is stopped when the **"shut-off angle"** search criteria is reached. The dwell angle achieved during the dwell time is then measured and the bolt backoff angle is processed in the control system together with the backoff evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

The graphics function is not supported in this stage.

The backoff torque is defined as being the force that must act upon a fastened joint in the specified direction in order to overcome the total of the pressing and frictional forces and thus back-off the fastener.

The parameters below are entered in the electronic control system:

Sequence input value: 41

Shut-off angle (Nm): Shut-off angle, backoff angle

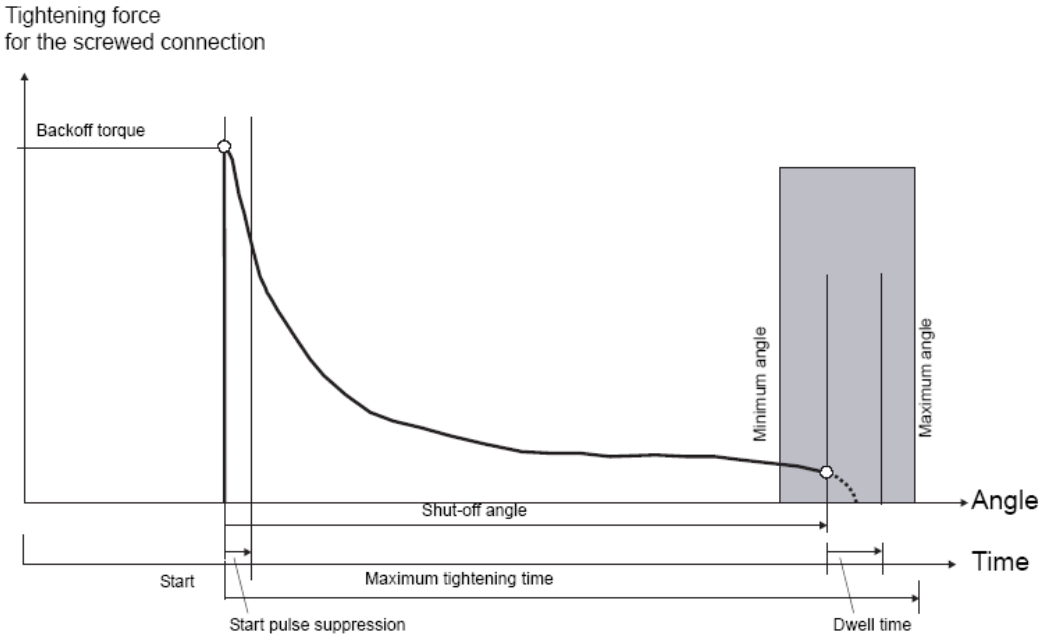
Maximum angle (deg): Maximum angle, high limit of angle reached

Minimum angle (deg): Minimum angle, low limit of angle reached

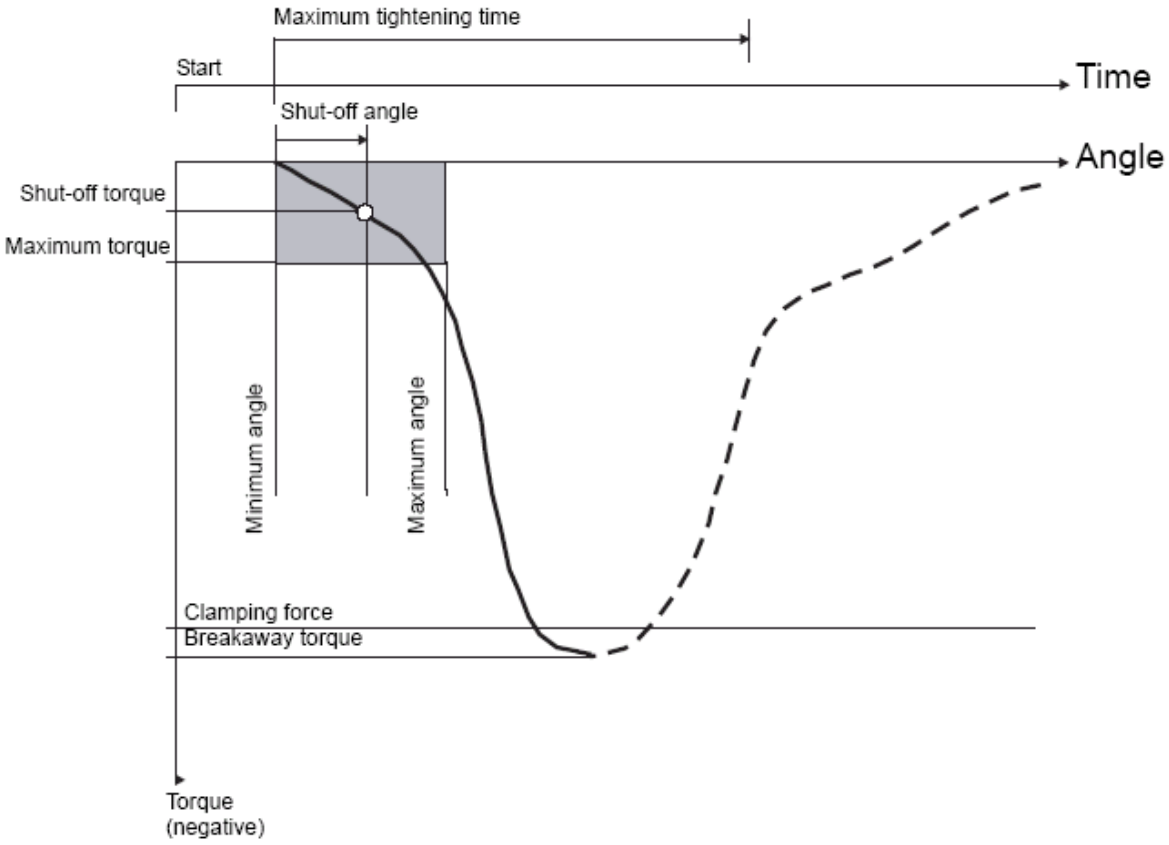
Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

In the figure above the process is shown correctly from the standpoint of measuring technology in which the measured torque is shown as being negative. The more interesting representation for the user shows the tensioning force of the screwed connection, which is shown below as being positive (equivalent to the tightening torque).



Sequence 46: Shut-off Angle and Shut-off Torque Controlled Releasing Strategy with Angle and Torque Monitoring Releasing Backoff Strategy with Freely Programmable Parameter Values



Seizing between the bolt head and bit often occurs during fastening. It can then be difficult to separate the tool from the workpiece, or an aid must be used for separation. Seizing occurs very frequently at high torques and / or with certain mechanical fixtures.

The spindle motor release may possibly not be transferred to the workpiece adaptor when the motor is shut off.

For this reason, a release can be carried out as the last operation in the automatic tightening process in the electronic control system. This should allow disconnection from the workpiece to be problem-free. This is achieved by reversing the fastening unit.

The releasing stage, which can be switched on and off, has fixed parameters that cannot be changed for this reversing.

Sequence 46 must be used for individual configuration. It is important here that the force closure for the fastened parts is released and never has more force applied in the reverse direction.

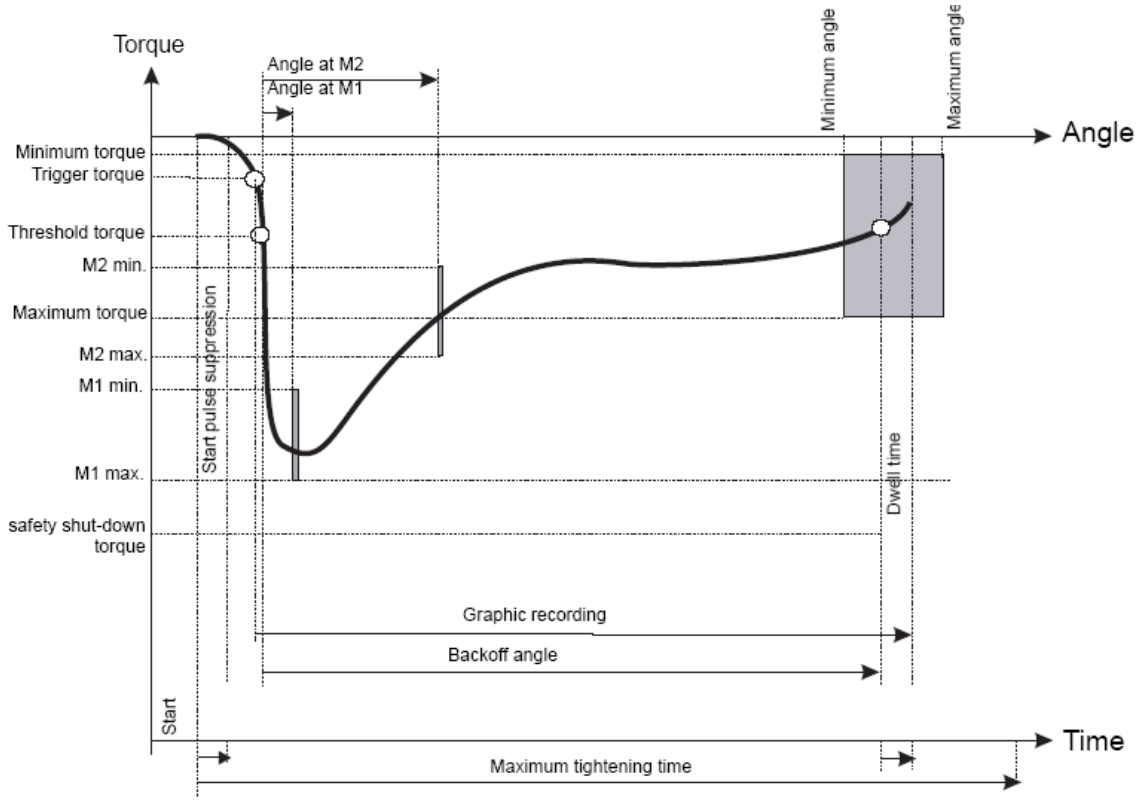
This would result in further tightening. Furthermore, the screwed connection can be backed off. The angle range that occurs for release is dependent upon the mechanical construction of the fastening unit. The stiffer the fastening mechanics and the more formfitting the tool (bit, square drive, ..), the smaller the releasing angle.
The graphics function is not supported in this stage.

The parameters below are entered in the electronic control system:

Sequence input value:	46
Shut-off angle (deg):	Shut-off angle, backoff angle
Maximum angle (deg):	Maximum angle, high limit of angle reached
Minimum angle (deg):	Minimum angle, low limit of angle reached
Shut-off torque (Nm):	Shut-off torque, shut-off value, that should prevent the screwed connection from backing off
Maximum torque (Nm):	Maximum torque, high limit of torque reached
Filtering factor:	Filtering factor, number of measured values used for filtering by averaging
Speed (rpm):	Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 48 Shut-off Angle Controlled Fastening with Backoff Angle and Residual Torque Monitoring

Sequence 48 is an angle-controlled sequence in which the two points can be defined at both of which a minimum and a maximum torque value must not be understepped or overstepped.



One check is carried out at each of the two points M1 and M2 in order to ascertain whether M1 min., M1 max. and M2 min., M2 max. torque limits are understepped or overstepped. Points M1 and M2 are specified by the angle at M1 and angle at M2 from the threshold torque.
Should the torque at these points not lay within the corresponding min/max limits the drive is stopped and the rundown data is evaluated as NOK.
The time sequence for the two points is not specified, i.e. M1 can lay to the left or right of M2 or at M2. The torque check in the points M1 and M2 can be deactivated individually by setting the angle at M1 or M2 to zero.

Safety shut-down torque parameters are set as an additional safety cutout. The drive is stopped when the safety shut-down torque is exceeded, which applies in the sequence from the end of the impulse suppression time up to the shut-off point. An error message with NOK evaluation is generated.
The torques at M1 and M2 as well as the maximum torques in the rundown are measured and the results are included in the statistical evaluation.

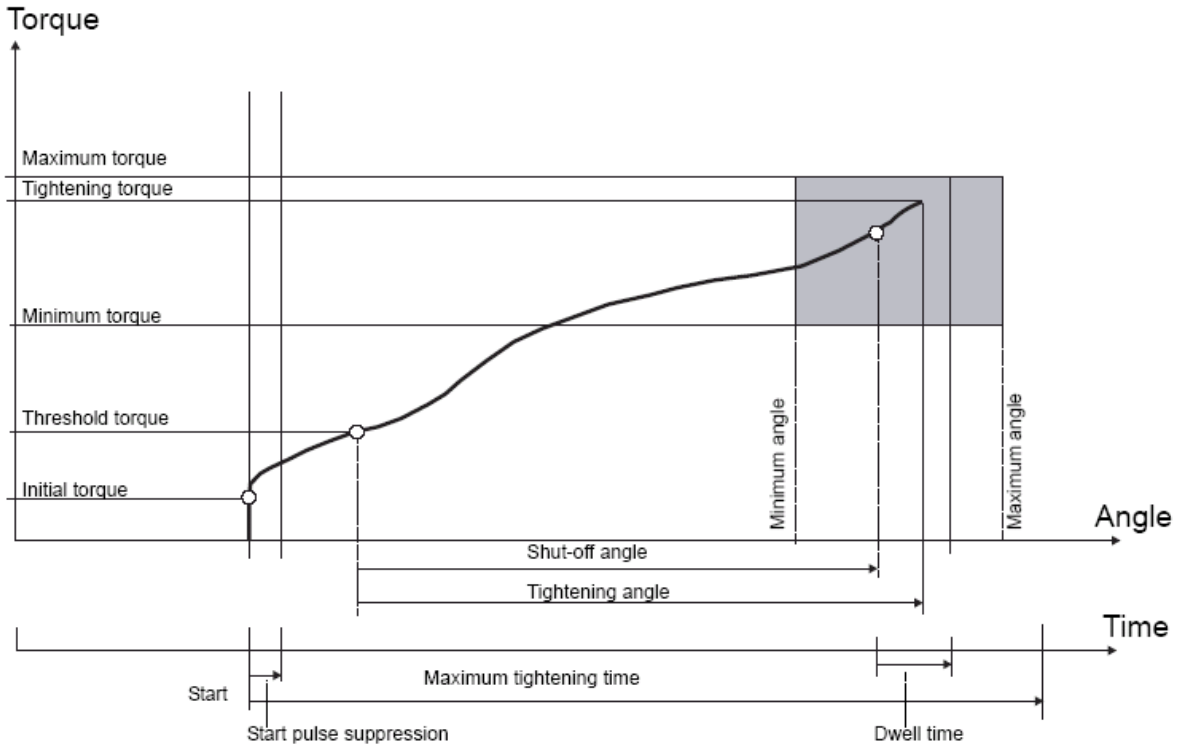
Angle counting starts from the threshold torque.
After switch-off due to the backoff angle having been reached, the minimum/maximum torque and the minimum/maximum angle are used to evaluate the result as OK or NOK. Parameters can be set for a maximum time, a start pulse suppression time and a dwell time.
When the trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

Description of parameters

Sequence input value:	48
Filtering factor:	Number of measured values used for averaging
Trigger torque (Nm):	Start of storing the torque value for the graphical view
Threshold torque (Nm):	Beginning of angle counting
Backoff angle (deg):	Angle at which the drive is stopped and the dwell time begins
Angle at M1 (deg):	Angle, at which the torque is checked at a position between M1 max. and M1 min.; the drive is stopped when the position lies outside of the range M1 min. to M1 max.
M1 max. (Nm):	Maximum torque allowed at M1
M1 min. (Nm):	Minimum torque allowed at M1
Angle at M2 (deg):	Angle, at which the torque is checked at a position between M2 max. and M2 min.; the drive is stopped when the position lies outside of the range M2 min. to M2 max.

M2 max. (Nm):	Maximum torque allowed at M2
M2 min. (Nm):	Minimum torque allowed at M2
Maximum torque (Nm):	High limit of torque reached in the shut-off point
Minimum torque (Nm):	Low limit of torque reached in the shut-off point
Maximum angle (deg):	High limit of angle reached in the shut-off point and shut-off value
Minimum angle (deg):	Low limit of angle reached in the shut-off point
Speed (rpm):	Preset speed; within the maximum speed range specified in the range for spindle constants
Safety shut-down torque (Nm):	Monitoring torque valid after start pulse suppression has finished and during the rundown, and the value at which the drive is stopped when it is exceeded

Sequence 50: Shut-off Angle Controlled Fastening with Angle and Torque Monitoring



In the electronic control system the shut-off angle, maximum angle, minimum angle, threshold torque, maximum torque, minimum torque, filtering factor and speed are entered separately for each nutsetter.

The maximum torque is also used as a safety shut-down. A maximum tightening time is entered as an additional safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The nutsetter is stopped when the "shut-off angle" search criteria is reached.

The dwell angle and peak torque achieved during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

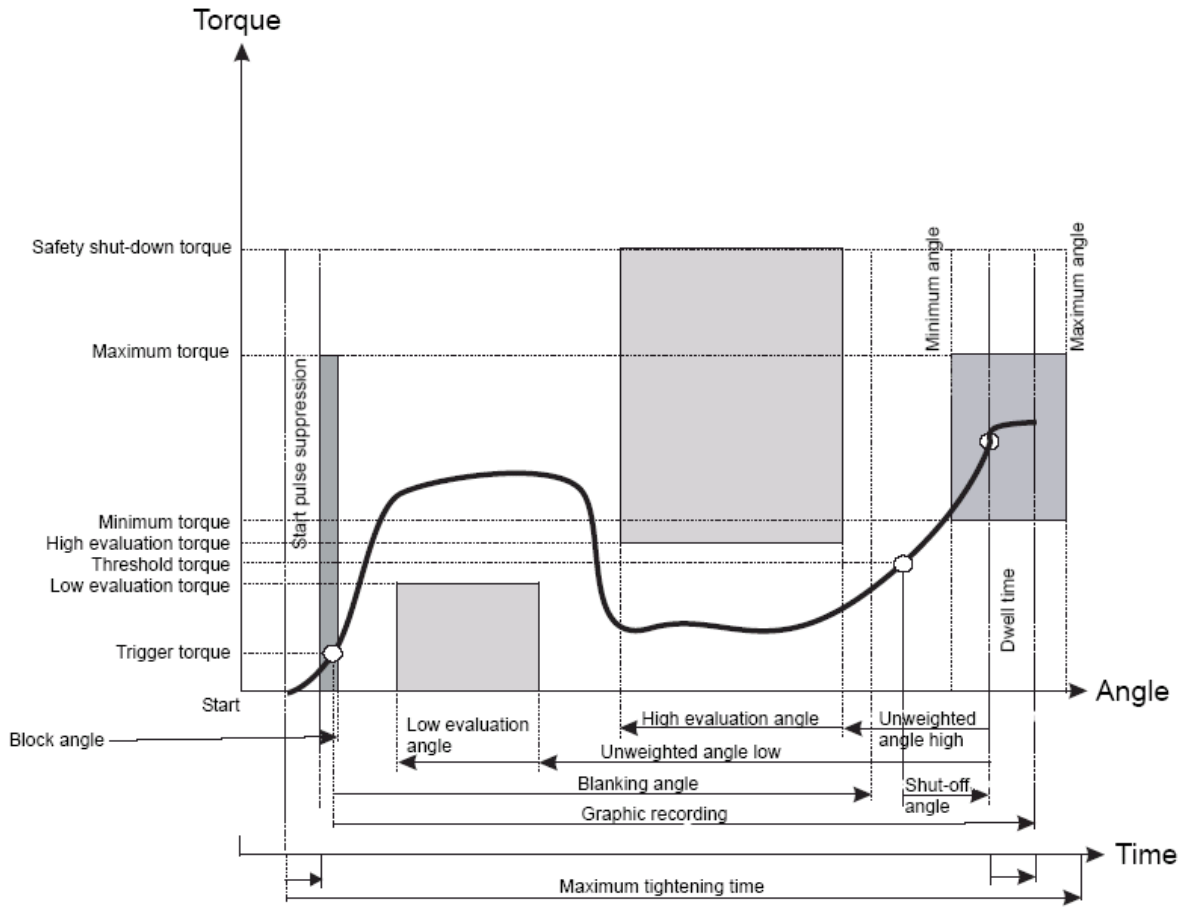
This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:
Sequence input value:

Trigger torque (Nm):	Trigger torque, beginning of measurement recording for the graphic display
Threshold torque (Nm):	Threshold torque, beginning of angle counting
Shut-off angle (deg):	Shut-off angle for the stage
Maximum angle (deg):	Maximum angle, high limit of angle reached
Minimum angle (deg):	Minimum angle, low limit of angle reached
Maximum torque (Nm):	Maximum torque, high limit of torque reached and shut-off value
Minimum torque (Nm):	Minimum torque, low limit of torque reached Torque
Filtering factor:	Filtering factor, number of measured values used for filtering by averaging
Speed (rpm)	Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 51: Shut-off Angle Controlled Fastening with Angle and Torque Monitoring

Sequence 51 is an angle-controlled sequence, which allows the rundown to be evaluated after the shut-off angle has been reached by means of reverse analysis over two monitoring ranges. Additionally, the monitoring torque can be changed by an angle range during the rundown.



The torque curve can be reverse analyzed after rundown is complete. This reverse analysis starts at the shut-off point (the dwell time is not considered) and is achieved using two separate angle ranges.
These angle ranges can be specified separately from one another by setting parameters for the end of the range (= unweighted angle high or low) and the length of the range (= evaluation angle high or low). The two evaluation angles can be in any order and also fully or partially overlap.

The high evaluation angle of the torque curve is checked for overstep of the evaluation torque and the low evaluation angle of the torque curve is checked for understep of the low evaluation torque. The tightening process is assessed as being NOK if there were oversteps and/or understeps.

The maximum torque is measured within the high evaluation angle, and the lowest torque value within the low evaluation angle and statistical evaluation is carried out. The evaluation torques can be deactivated by setting the corresponding evaluation angle to zero.

In the **block angle** range, which begins directly after the start pulse suppression, the torque must not exceed the maximum torque as this will stop the drive. This serves to detect rundowns that are carried out on a tightened bolt. The block angle can be deactivated by setting it to zero.

The torque curve is recorded for the graphic starting from the **trigger torque** (1 torque value per angle degree). These values are also the basis for the reverse analysis. Therefore, the trigger torque must be parametrized so that the torque curve relevant for reverse analysis is always recorded!

An error message with NOK evaluation is generated if there are insufficient torque values for reverse analysis. The torque curve can be output as a graphic.

Parameters can be set for a blanking angle that starts when trigger torque is reached. During the blanking angle, detection of the **threshold torque** and maximum torque is deactivated and is only reactivated after the blanking angle has finished.
It is permissible for the torque to be higher than the maximum torque in the blanking angle, but the safety shut-down torque must not be exceeded. The drive is stopped when the safety shutdown torque is exceeded, which applies in the sequence from the end of the start pulse suppression time up to the shut-off point. An error message with NOK evaluation is generated. The blanking angle can be deactivated by setting it to zero.
If the block angle and blanking angle overlap, the maximum torque is considered to be a termination criteria until the end of the block angle.

Angle counting starts when the threshold torque is reached if detection of the threshold torque has not been deactivated by the block angle or blanking angle.

Note: If the threshold torque = trigger torque, then angle counting starts when the threshold torque is reached and continues in the blanking angle. Angle measurement and possibly also redundancy monitoring starts when the drive starts.

After the shut-off torque has caused a shut-down, the corresponding angle and/or the torque are compared to the minimum/maximum angle and the minimum/ maximum torque and evaluated accordingly as OK or NOK. Reverse analysis is also carried out.

The maximum angle, maximum torque, safety shut-down torque and maximum tightening time for the stage are used as a safety shut-down.

Description of Parameters

Sequence input value: 51

Filtering factor: Number of measured torque values used for averaging

Trigger torque (Nm): Beginning of storing torque values for the graphic display, reverse analysis and blanking angle

Threshold torque (Nm): Beginning of angle counting; valid outside the blanking angle and block angle

Safety shut-down torque (Nm): Monitoring torque valid after start pulse suppression has finished and during the rundown, and the value at which the drive is stopped when it is exceeded

Shut-off angle (deg): Angle at which the drive is stopped and the dwell time begins;

Block angle (deg): Angle, beginning at the end of start pulse suppression, in which the torque must be lower than the maximum torque

Blanking angle (deg): Angle range starting at the trigger torque, in which the maximum torque and threshold torque are invalid

Unweighted angle high (deg): End point of the evaluation angle high, related to the shut-off point (reverse)

Evaluation angle high (deg): Length of the monitored range for overstep of the high evaluation torque

High evaluation torque (Nm): High torque limit in the evaluation angle high that must not be exceeded in reverse analysis

Unweighted angle low (deg):	End point of the evaluation angle low, related to the shut-off point (reverse)
Evaluation angle low (deg):	Length of the monitored range for understep of the low evaluation torque
Low evaluation torque (Nm):	Low torque limit in the evaluation angle low that must not be understepped in reverse analysis
Maximum torque (Nm):	High limit of torque reached
Minimum torque (Nm):	Low limit of torque reached
Maximum angle (deg):	High limit for angle reached and safety shut-off value
Minimum angle (deg):	Low limit of angle reached
Speed 1 (rpm):	Preset speed; maximum speed specified in the range for spindle constants, valid from the beginning of the sequence up to the threshold torque
Speed 2 (rpm [1]):	Speed when the maximum torque is reached. Must be lower than speed 1. Cutoff is deactivated when speed 2 = 0 or speed 2 ≧ speed 1

[1] The maximum torque is normally not reached; the torque shut-off value is lower than the maximum torque, so the speed will not fully cut off to speed 2.

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Validity of Individual Parameters

Parameter	Start	End	Sequence for evaluation	Suppressed in
Threshold torque	After start pulse suppression	Shut-off point reached	1	Block angle, blanking angle
Safety torque shut-down			2	---
Shut-off angle			3	---
Trigger torque			4	---

When the values are equal the sequence for evaluation causes a higher priority for evaluation, for instance, of the threshold torque before the trigger torque, i.e. the threshold torque and thus angle counting are activated when the trigger torque and threshold torque have the same numeric values, even if a blanking angle is defined.

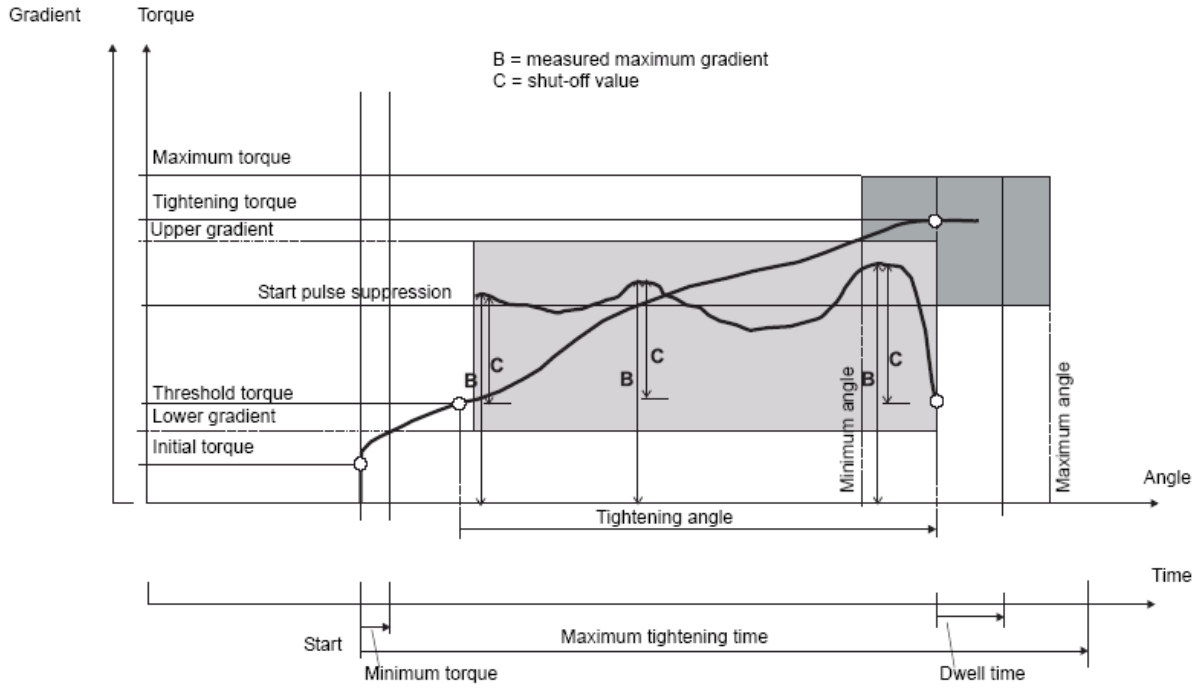
Parameter	Start	End	Deactivation
Blanking angle	Trigger torque	After blanking angle degree	Blanking angle = 0
Block angle	After start pulse sup-pression	After block angle degree	Block angle = 0
Speed 1	At spindle start	1) Shut-off point when speed 2 = 0 2) Threshold torque when speed 2 > 0	---
Speed 2	From threshold torque	Shut-off point	Speed 2 = 0 or speed 2 ≥ speed 1

Parameters that are analyzed in reverse, i.e. starting from the shut-off point

Parameter	Start	End	Deactivation
High evaluation angle	Shut-off point minus upper unweighted angle	Shut-off point minus upper unweighted angle minus high evaluation angle	High evaluation angle = 0
Upper unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
High evaluation torque	Valid in the high evaluation angle		High evaluation angle = 0
Low evaluation angle	Shut-off point minus lower unweighted angle	Shut-off point minus lower unweighted angle minus low evaluation angle	Low evaluation angle = 0
Lower unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
Low evaluation torque	Valid in the low evaluation angle		Low evaluation angle = 0

Sequence 63: Yield Point Controlled Fastening with Torque, Angle and Gradient Monitoring

Yield point controlled fastening with percentage preset of the shut-off gradients by the maximum gradient and torque, rotation angle and gradient monitoring.



In the electronic control system the lower gradient, upper gradient, percentage shut-off value, strobe multiplier, filtering factor, minimum torque, maximum torque, minimum angle, maximum angle and speed are entered separately for each nutsetter.
The maximum torque, maximum angle as well as the upper and lower gradients are also used as a safety shut-down.

A maximum tightening time is entered as an additional safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The nutsetter is stopped when the **"shut-off gradient"** (percentage rate of the currently measured maximum gradient) search criteria is reached. The dwell angle and peak torque during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

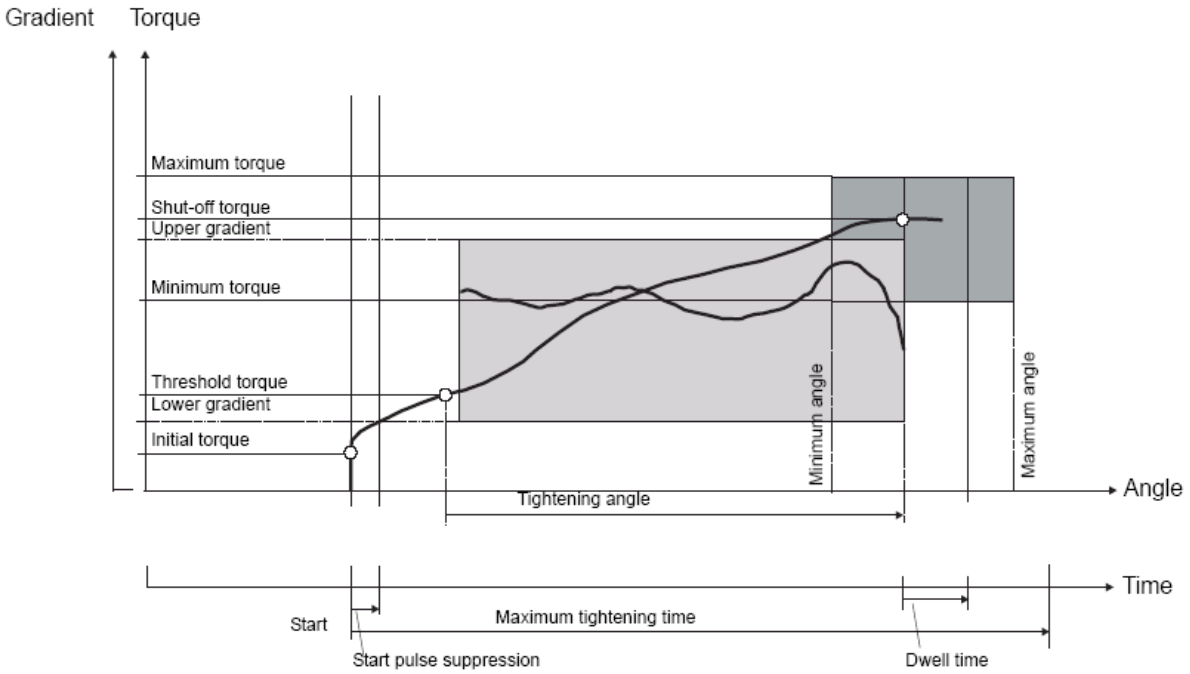
When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value:	63
Trigger torque (Nm):	Trigger torque, beginning of measurement recording for the graphic display
Threshold torque (Nm):	Threshold torque, beginning of angle counting and gradient calculation
Perc. shut-off value (%):	Percentage shut-off value, percentage amount of the measured maximum gradients for the rundown produces the shut-off value (shut-off gradient)
Minimum gradient (Nm/deg):	Minimum gradient, low limit and safety shut-off value for the gradient
Maximum gradient (Nm/deg):	Maximum gradient, high limit and safety shut-off value for the gradient
Strobe multiplier:	Strobe multiplier, spacing in angle impulses of the filtered measured values used for gradient calculation
Filtering factor:	Filtering factor, number of measured values used for filtering by averaging
Maximum angle (deg):	Maximum angle, high limit for angle reached and safety shut-off value
Minimum angle (deg):	Minimum angle, low limit of angle reached
Maximum torque (Nm):	Maximum torque, high limit of torque reached and shut-off value
Minimum torque (Nm):	Minimum torque, low limit of torque reached
Speed (rpm):	Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 73: Shut-off Torque Controlled Fastening with Torque, Angle and Gradient Monitoring



In the electronic control system the **shut-off torque**, maximum torque, minimum torque, maximum angle, minimum angle, lower gradient, upper gradient, strobe multiplier, filtering factor and speed are entered separately for each nutsetter. The maximum angle is also used as a safety shut-down.

A maximum tightening time is entered as an additional safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The nutsetter is stopped when the **"shut-off torque"** search criteria is reached. The dwell angle and peak torque during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values as text or in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value: 73

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

Threshold torque (Nm): Threshold torque, beginning of angle counting and gradient calculation

Shut-off torque (Nm): Shut-off torque for the stage

Maximum torque (Nm): Maximum torque, high limit of torque reached

Minimum torque (Nm): Minimum torque, low limit of torque reached

Maximum angle (deg): Maximum angle, high limit for angle reached and safety shut-off value

Minimum angle (deg): Minimum angle, low limit of angle reached

Minimum gradient (Nm/deg): Minimum gradient, low limit of the gradients

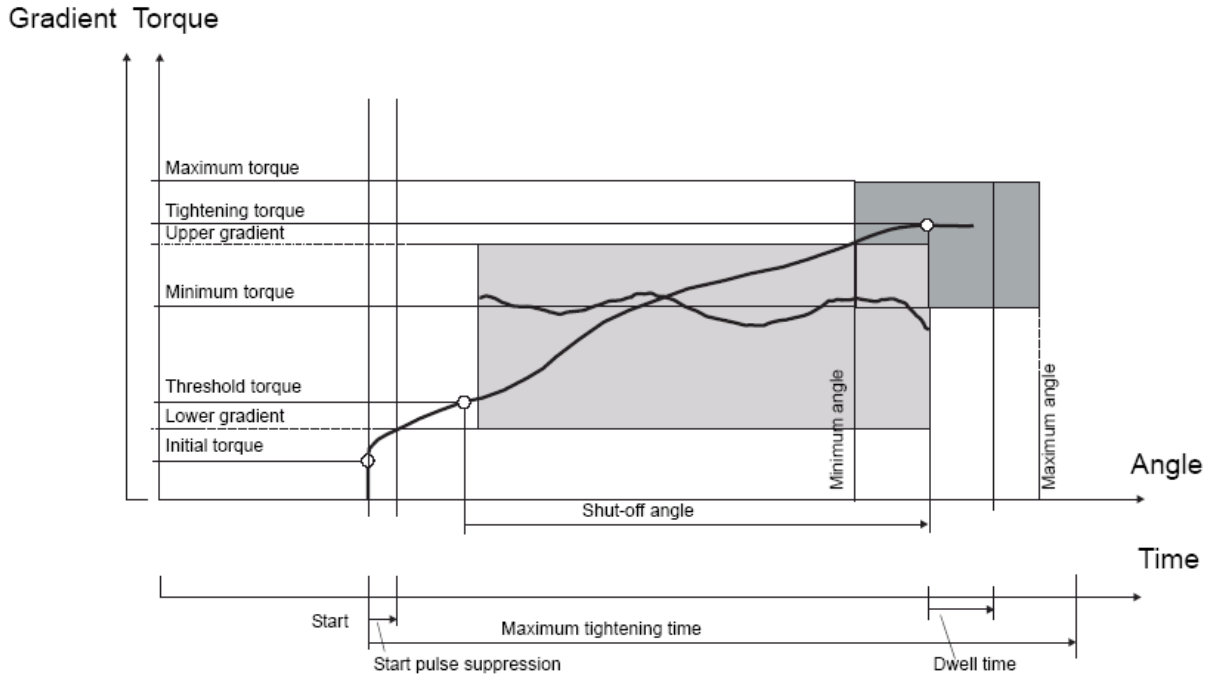
Maximum gradient (Nm/deg): Maximum gradient, high limit of the gradients

Strobe multiplier: Strobe multiplier, spacing in angle impulses of the filltered measured values used for gradient calculation

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 75: Shut-off Angle Controlled Fastening with Torque, Angle and Gradient Monitoring



In the electronic control system the shut-off angle, maximum angle, minimum angle, maximum torque, minimum torque, lower gradient, upper gradient, strobe multiplier, filtering factor and speed are entered separately for each nutsetter. The maximum torque is also used as a safety shut-down.

A maximum tightening time is entered as an additional safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The nutsetter is stopped when the "shut-off angle" search criteria is reached. The dwell angle and peak torque during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value: 75

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

Threshold torque (Nm): Threshold torque, beginning of angle counting and gradient calculation

Shut-off angle (deg): Shut-off angle for the stage

Maximum angle (deg): Maximum angle, high limit of angle reached

Minimum angle (deg): Minimum angle, low limit of angle reached

Maximum torque (Nm): Maximum torque, high limit of torque reached and shut-off value

Minimum torque (Nm): Minimum torque, low limit of torque reached

Minimum gradient (Nm/deg): Minimum gradient, low limit of the gradients

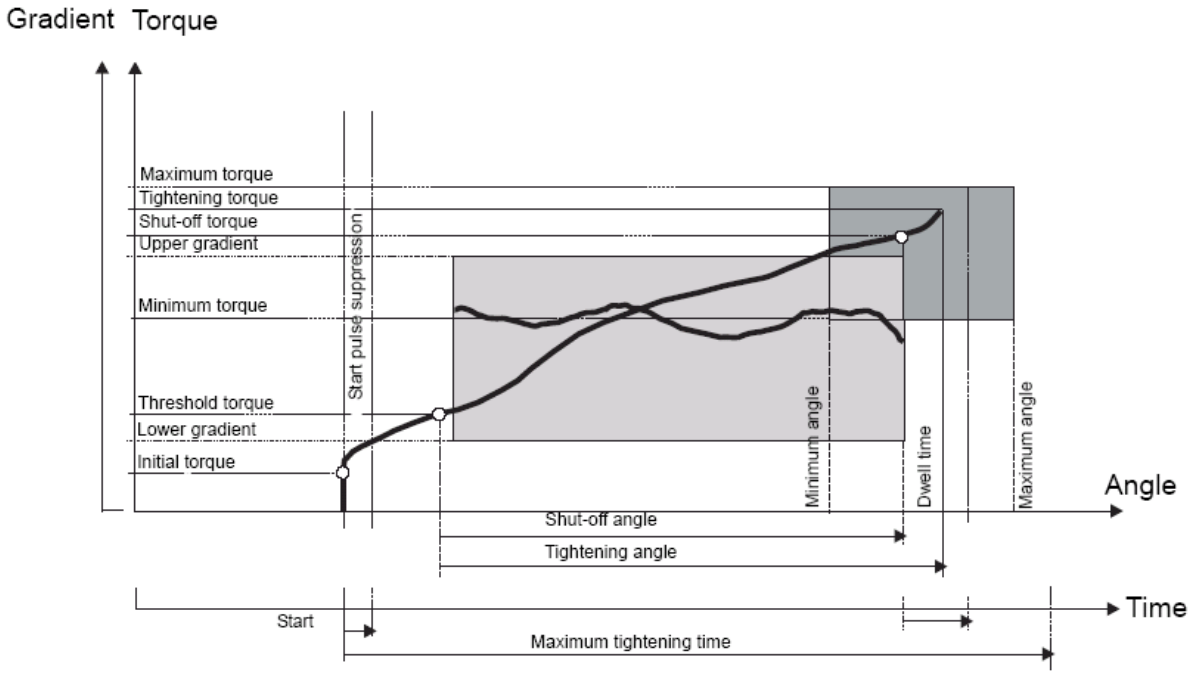
Maximum gradient (Nm/deg): Maximum gradient, high limit of the gradients

Strobe multiplier: Strobe multiplier, spacing in angle impulses of the filtered measured values used for gradient calculation

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 78: Shut-off torque and shut-off Angle Controlled Fastening with Torque, Angle and Gradient Monitoring



In the electronic control system the shut-off torque, **shut-off angle**, maximum angle, minimum angle, maximum torque, minimum torque, lower gradient, upper gradient, strobe multiplier, filtering factor and speed are entered separately for each nutsetter.
A maximum tightening time is entered as the safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.
The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The nutsetter is stopped when the "shut-off torque" or "shut-off angle" search criteria is reached. The dwell angle and peak torque during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.
When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value: 78

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

Threshold torque (Nm): Threshold torque, beginning of angle counting and gradient calculation

Shut-off torque (Nm): Shut-off torque for the stage

Shut-off angle (deg): Shut-off angle for the stage

Maximum angle (deg): Maximum angle, high limit of angle reached

Minimum angle (deg): Minimum angle, low limit of angle reached

Maximum torque (Nm): Maximum torque, high limit of torque reached and shut-off value

Minimum torque (Nm): Minimum torque, low limit of torque reached

Minimum gradient (Nm/deg): Minimum gradient, low limit of the gradients

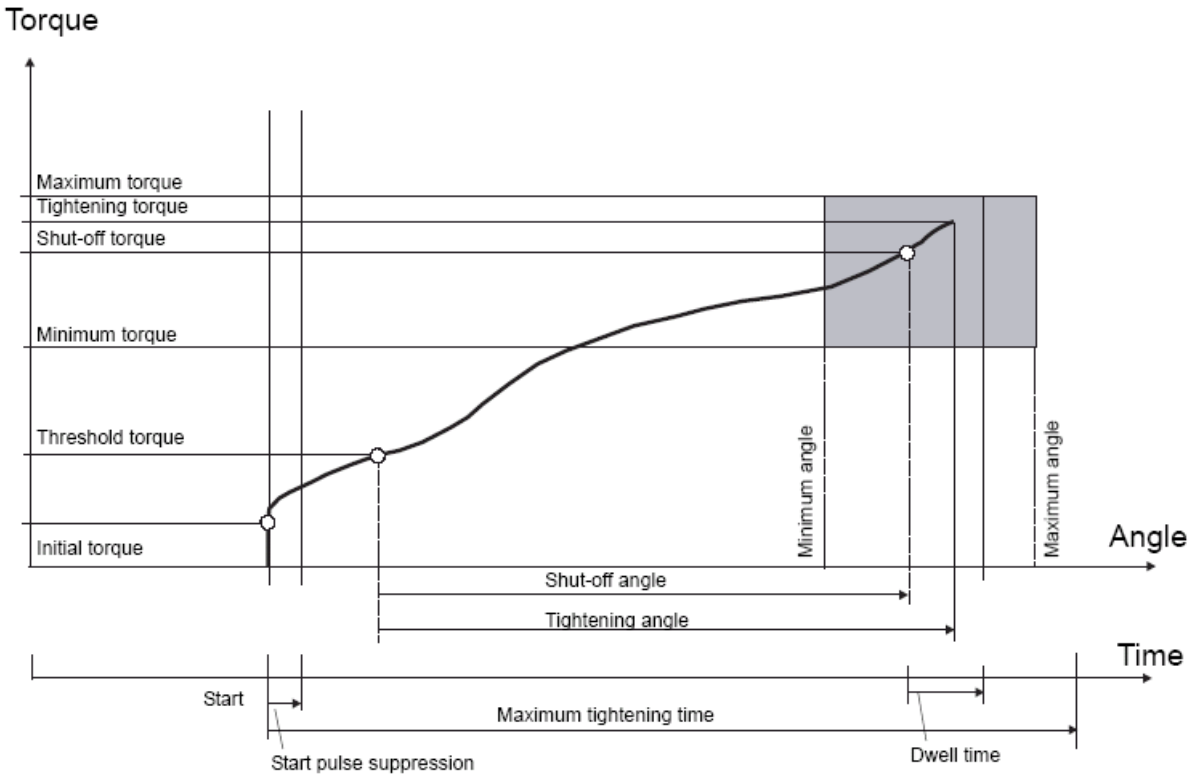
Maximum gradient (Nm/deg): Maximum gradient, high limit of the gradients

Strobe multiplier: Strobe multiplier, spacing in angle impulses of the filtered measured values used for gradient calculation

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Sequence 80: Shut-off Torque and Shut-off Angle Controlled Fastening with Angle and Torque Monitoring



In the electronic control system the shut-off torque, shut-off angle, maximum angle, minimum angle, threshold torque, maximum torque, minimum torque, filtering factor and speed are entered separately for each nutsetter.

The maximum torque and the maximum angle are also used as a safety shut-down. A maximum tightening time is entered as an additional safety shut-down. It applies to all nutsetters of a product group (tightening process) in this stage.

The measuring transducer integrated into the nutsetter measures the torque and rotation angle during tightening rundown. The values are processed by the control system. The nutsetter is stopped when the "shut-off torque" or "shut-off angle" search criteria is reached. The dwell angle and peak torque achieved during the dwell time are then measured and processed in the control system as the bolt tightening value together with the rundown evaluation. The control system can display the values in tables on the monitor and can output them to a printer or transmit them to other system components by data communication.

When the spindle trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

This tightening method normally follows a fast pretightening stage.

The parameters below are entered in the electronic control system:

Sequence input value: 80

Trigger torque (Nm): Trigger torque, beginning of measurement recording for the graphic display

Threshold torque (Nm): Threshold torque, beginning of angle counting

Shut-off torque (Nm): Shut-off torque for the stage

Shut-off angle (deg): Shut-off angle for the stage

Maximum angle (deg): Maximum angle, high limit for angle reached and safety shut-off value

Minimum angle (deg): Minimum angle, low limit of angle reached

Maximum torque (Nm): Maximum torque, high limit of torque reached and shut-off value

Minimum torque (Nm): Minimum torque, low limit of torque reached

Filtering factor: Filtering factor, number of measured values used for filtering by averaging

Speed (rpm): Preset speed; within the maximum speed range specified in the range for spindle constants

Pre-Rundown and Post Rundown Fastening Strategies

There are several pre-rundown and post rundown strategies which can be enabled which attach to a Fastening Sequence. When a pre-rundown strategy is enabled, it will run before the Stage 1 Sequence begins. When a post-rundown strategy is enabled, it will run when the last Programmed Stage “n” Sequence has completed the cycle.

Pre-Rundown Fastening Strategies

- Jog

Post Rundown Fastening Strategies

- Touchup and Error Handling
- PTR (pulse torque recovery)

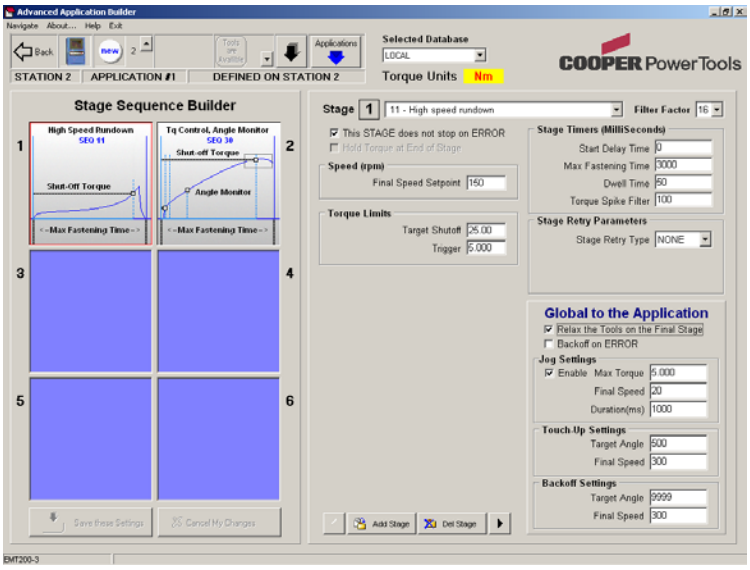
Pre-Rundown Fastening Strategy – JOG

The JOG function provides a way to rotate the tool spindle in short duration intervals for the purpose of locating the socket(s) on the bolt or nut. Pressing the cycle start lever for short intervals can be repeated until the sockets are settled on the fastener. No declaration of OK or NOK is made during the jogs. If the operator holds the cycle start lever down longer than the programmed jog duration time, the rundown will automatically proceed to Stage 1 to the end of the rundown.

This procedure describes the enabling of JOG and the JOG parameter programming.

The JOG setup parameters are located on the Advanced Application Builder screen.

1. Click on Navigate, upper left of the screen.
2. Click on Advanced Application Builder.
3. Refer to the following illustration of the Advanced Application Builder screen.
4. On the lower right of the Application Builder Screen is a section labeled **Jog Settings**.
5. Place a check mark in the Enable block
6. Enter the Max Torque. If the max torque is exceeded during JOG, the jog process will stop.
7. Enter the Final Speed. This is the spindle speed during the JOG process.
8. Enter the Duration in msec. JOG intervals less than this interval will not start the rundown, and can be repeated any number of times at the operator's discretion. If the Duration time is exceeded, the rundown cycle will begin automatically starting with Stage 1. As an example, set the duration at 3000 for a 3 second JOG duration.

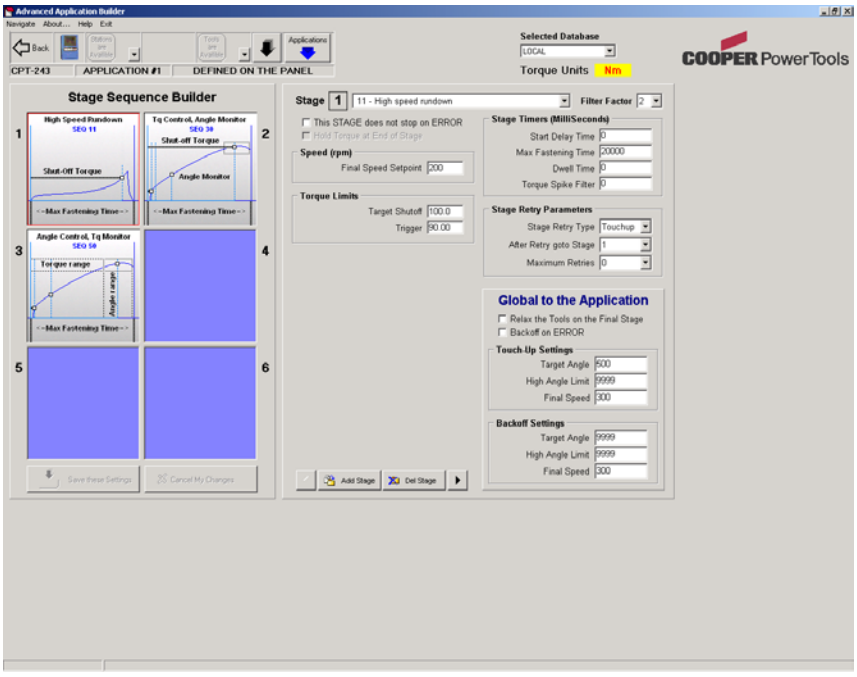


Post-Rundown Fastening Strategy – TOUCH UP and ERROR HANDLING

The TOUCH UP / ERROR-HANDLING function provides a way to program Error-Handling by programming a NOK (not OK, reject) strategy. Subsequent to touch up another fastening stage may be started, while error-handling leads to the end of the process. This allows to back off joints in the touch up routine and to retighten these in the further fastening sequence to achieve an OK (accept) rundown. Since no further stage can follow the error-handling routine, the fastening sequence is terminated with NOK, it is often used to fully back out the fasteners.

Touch up and error handling can be programmed separately for each fastening stage, that is, group assignments and blackout parameters can be entered in each stage for both touch up and error-handling.

Touch up is performed immediately after the end of a fastening stage. Error-handling can be initiated by any fastening stage, but will performed after the last fastening stage with the stage related back off parameters.



From the Navigate drop down panel (upper left corner of screen), select Advanced Application Builder. The **"Global to the Application"** area on the lower right of the Advanced Application Builder screen contains the parameter settings for Touch Up and Back out.

Touch Up Settings

- Target Angle
- High Angle Limit
- Final Speed

Backoff Settings

- Target Angle
- High Angle Limit
- Final Speed

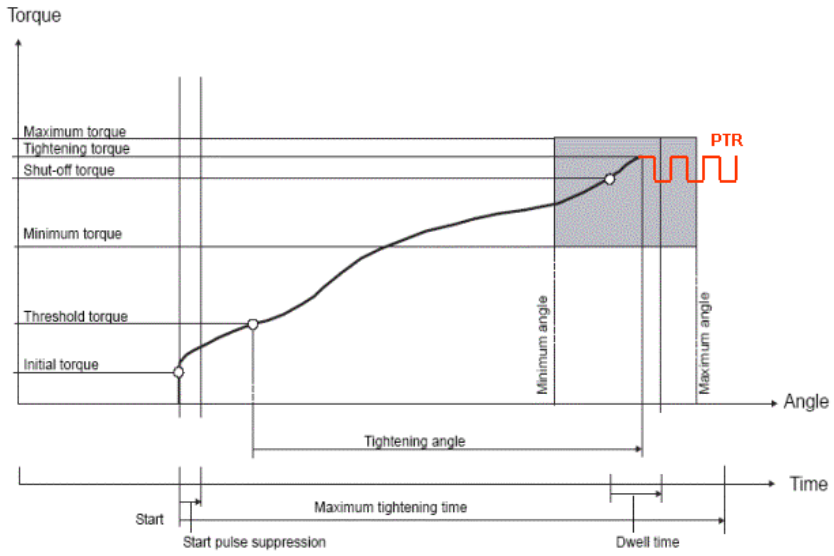
Post-Rundown Fastening Strategy – PTR (Pulse torque recovery)

The Pulse Torque Recovery (PTR) function provides a way to program torque recovery by pulsing “make-up” torque at the conclusion of a fastening rundown, and is used most successfully on joints which are either gasketed, springy sheet metal, or soft metal (aluminum) where a "make-up torque" is required. If the joint begins to relax immediately following the rundown, PTR can add a pre-programmed amount of torque for a pre-programmed time duration if the torque drops below a pre-programmed value. This strategy was awarded U.S. Patent 5,094,301.

Pulse torque recovery is applied at the conclusion of a fastening rundown, and is used most successfully on joints which are either gasketed or springy sheet metal, where a "makeup torque" is required. If the joint begins to relax immediately following the rundown, Torque Recovery can add a pre-programmed amount of torque for a pre-programmed time duration if the torque drops below a pre-programmed value. This strategy was awarded U.S. Patent 5,094,301.

PTR can be applied to the final stage attached to either Sequence 20 PTR, Pulse Torque Recovery or Sequence 30 PTR. Shut-off Torque Controlled Fastening with Torque Monitoring and Angle Monitoring.

The rundown graphic for Sequence 30 PTR appears below:



For Sequence 30 PTR, the only parameter to program is the qty of pulses. The approximate pulse period of PTR is about 150 msec. If the number of pulses was programmed as qty 14, the PTR duration would be 14 X 150 msec, or about 2 seconds duration.

For Sequence 20 PTR, the following parameters can be programmed:

- On time in msec
- Off time in msec
- High Limit Torque
- Low Limit Torque
- Qty pulses
- Spindle speed

Fastening Strategies

This Section discusses twenty-two different fastening strategies. These fastening strategies are all resident within the TM Tightening Modules (servos). Some of the strategies are independent, and are assigned a Sequence Number. Some of the strategies are dependent and when enabled, support an independent sequence. An example of a dependent strategy is Pulse Torque Recovery (PTR) which can be assigned to Sequences 20, 30 or 50. The following table lists each Fastening Strategy and the assigned Sequence number.

Fastening Strategy Name	Sequence Number
Engagement Stage	10
High Speed Rundown	11
Prevailing Torque Monitor	13
Drag Torque Monitor	15
Set Position	16
Torque Control	20
Torque Control, Pulse Torque Recovery	20PTR
Torque Control, Angle Monitor	30
Torque Control, Angle Monitor, Pulse Torque Recovery	30PTR
Self-Tap with Torque Control	31
Torque Maintenance with Switch-off Torque Control	33
Backoff Angle Monitoring (Reverse)	41
Backoff Angle / Torque Monitoring	46
Backoff Angle Control with 2 Torque Monitoring Points	48
Angle Control, Torque Monitor	50
Angle Control with Angle and Torque Monitoring	51
Yield Point Control	63
Torque Control, Angle and Gradient Monitoring	73
Angle Control, Torque and Gradient Monitor	75
Torque Control, Angle and Gradient Monitor	78
Torque Control, Angle Monitor	80
Relax	Parameter Set 193

Fastening Strategies – Short Description

Sequence 10 "Engagement Stage"

Sequence 10 is designed to engage the nut-runner on the fastener. This is achieved by alternating the nut-runner counterclockwise and clockwise to engage the fastener.

Sequence 11 "High Speed Rundown"

Sequence 11 is designed to minimize the time to reach snug-torque. This is achieved by programming a higher speed prior to a lower speed control sequence.

Sequence 13 "Prevailing Torque Monitor"

Sequence 13 is designed to monitor fastening prevailing torque by enabling a high and low limit. The prevailing monitor can be programmed between angle limits.

Sequence 15 "Drag Torque Monitor"

Sequence 15 is designed as a special feature. It is the measurement of bearing and shaft drag torque. For example: an engine crankshaft rotational measurement.

Sequence 16 "Set Position"

Sequence 16 is a special purpose strategy which is used to line up a cotter pin hole in a bolt with the space in a castellated nut. For example: a wheel bearing nut assembly.

Sequence 20 "Torque Control"

Sequence 20 is a general fastening control strategy. This strategy answers out to controlled torque.

Sequence 20PTR "Torque Control and Pulse Torque Recovery"

Sequence 20 is a general fastening control strategy. This strategy answers out to controlled torque. At the conclusion of the rundown, pulse torque recovery (PTR) is run for a user programmable number of torque on-off makeup pulses.

Sequence 30 "Torque Control with Angle Monitoring"

Sequence 30 is a general fastening control strategy. This strategy answers out to controlled torque and monitors angle.

Sequence 30PTR "Torque Control with Angle Monitoring and Pulse Torque Recovery"

Sequence 30 is a general fastening control strategy. This strategy answers out to controlled torque and monitors angle. At the conclusion of the rundown, pulse torque recovery (PTR) is run for a user programmable number of torque on-off makeup pulses.

Sequence 31 "Self-Tap with Torque Control"

Sequence 31 is designed to initially monitor the torque required for a self tap screw to cut a thread, and then control torque for final clamp load.

Sequence 41 "Back-off with Angle Control"

Sequence 41 is a controlled reverse strategy using angle control.

Sequence 46 "Back-off with Torque and Angle Control"

Sequence 46 is a controlled reverse strategy using both torque and angle control.

Sequence 48 "Back-off with 3 stage Torque and Angle Control"

Sequence 48 is a controlled angle reverse strategy with 2 Torque Monitoring Points.

Sequence 50 "Angle Control with Torque Monitoring"

Sequence 50 is a general fastening control strategy. This strategy answers out to controlled angle and monitors torque.

Sequence 51 "Self-Tap with Angle Control"

Sequence 51 is designed to initially monitor the torque required for a self tap screw to cut a thread, and then control angle for final clamp load.

Sequence 63 "Yield Point Control"

Sequence 63 is designed to repeatably control a joint to several thousandth inches of permanent bolt elongation. This is accomplisher by controlling gradient and monitoring torque and angle.

Sequence 73 "Torque Control with Yield Monitoring"

Sequence 73 is designed to answer out to a control torque while monitoring yield.

Sequence 75 "Angle Control with Yield Monitoring"

Sequence 75 is designed to answer out to a control angle while monitoring yield.

Sequence 78 "Torque and Angle Control with Yield Monitoring"

Sequence 78 is designed to answer out to a control torque and angle (which ever comes first) while monitoring yield.

Sequence 80 "Torque and Angle Control with Torque and Angle Monitoring"

Sequence 80 is designed to control torque and angle (which ever comes first) with torque and angle monitoring.

Sequence Parameter 193 "Relax"

Sequence Parameter 193 is designed to relax pressure on the spindle sockets by reversing 1 to 3 degrees at the conclusion of a rundown. This permits easy withdraw of the multiple spindles from the part.

Sequence	Sequence Description	TMMT Version	TM Firmware	NOTES
10	Engagement	1.4	2.07	
11	High speed rundown	1.0	2.07	Shut-off torque controlled fastening up to a contact torque
13	Free rundown torque monitoring (CA: Prevailing Torque Monitor)	1.4	2.07	Shut-off torque controlled fastening up to a contact torque with partially monitored torque monitoring during tightening plus subsequent torque analysis.
15	Frictional torque measurement (CA: Drag Torque Monitor)	1.4	2.07	
16	Event-dependent turning (CA: Set Position)	1.4	2.07	The purpose of this sequence is to stop the built-in nutsetter after a specified initiator position or a defined angle shut-off value in order to obtain an exact ("upper dead center") position for the machining workpiece.
20	Torque control with torque monitoring	1.4	2.07	
20ptr	Torque control with torque monitoring plus Pulse Torque Recovery	1.4	2.07	
21	Counter holding	unsupported		The purpose of this sequence is to be used as a counter-spindle (retaining spindle) when counter-locking rundowns. The counter-spindle applies the counter torque to the corresponding spindle.
30	Torque control with torque and angle monitoring	1.0	2.07	
30ptr	Torque control with torque and angle monitoring with Pulse Torque Recovery	1.0	2.07	
31	Torque control with torque and angle monitoring	1.6		Torque-controlled sequence, which allows the rundown to be evaluated after the shut-off torque has been reached by means of reverse analysis over two monitoring ranges.
33	Torque maintenance with shutoff torque control	1.11x	-117	Switch-off torque controlled tightening procedure with torque maintenance and automatic retightening
41	Angle controlled back-off with back-off angle monitoring	1.0	2.07	
44	Angle controlled back-off with back-off angle and residual torque monitoring	unsupported		
45	Angle controlled releasing back-off strategy with back-off angle and maximum torque monitoring	unsupported		

Sequence	Sequence Description	TMMT Version	TM Firmware	NOTES
46	Angle and shut-off torque controlled releasing strategy with angle and torque monitoring	1.4	2.07	Releasing back-off strategy with freely programmable parameter values.
48	Angle control with back-off angle and residual torque monitoring	1.6		Angle-controlled sequence in which the two points can be defined at both of which a minimum and a maximum torque value must not be understepped or overstepped.
50	Angle control with angle and torque monitoring	1.0	2.07	
51	Angle control with angle and torque monitoring	1.6		Angle-controlled sequence, which allows the rundown to be evaluated after the shut-off angle has been reached by means of reverse analysis over two monitoring ranges. The monitoring torque can also be changed by an angle range during the rundown.
55	Frictional torque measurement with external spindle	unsupported		
56	Frictional torque measurement with angle monitoring	unsupported		
63	Yield point control with torque, angle and gradient monitoring	1.1	2.13	Yield point controlled fastening with percentage preset of the shut-off gradients by the maximum gradient and torque, rotation angle and gradient monitoring.
73	Torque control with torque, angle and gradient monitoring	1.4	2.07	
75	Angle control with torque, angle and gradient monitoring	1.4	2.07	
78	Torque and shut-off angle control with torque, angle and gradient monitoring	1.4	2.07	
80	Torque and angle control with angle and torque monitoring	1.4	2.07	
94	Direction center adjustment	unsupported	2.07	

General Information on Fastening Techology

Overview

A threaded fastener connection is a removable connection of two or more parts that utilizes one or more bolts. The bolts and their tensioning forces must be properly dimensioned to ensure the resulting joint can serve its purpose and withstand the existing operating forces. Calculation of a screwed connection is based on the operating force applied to the joint from outside. This operating force results in axial forces, transverse forces, bending force and torque.
Only on simple symmetric and relatively rigid joints it is possible to split up the operating force to develop a practical calculation method. For eccentrically strained joints this is possible only to a limited extent or not at all. The purpose of calculation of the screwed connection is to determine the size of the fasteners.

The following properties must be considered:

Shore hardness of the bolt

The determining factor for the dimension of the bolt is the yield point. Generally it should not be exceeded when the bolt is tightened to the rated tension and when the joint is exposed to strain.
Only under special preconditions, such as angle controlled tightening, it is admissible to exceed the yield point. Further criteria are the elongation at rupture, the tenacity of the head and the notched bar impact value (see DIN 267-3: 1967 and DIN ISO 898).
Generally the following is true: high-strength bolts (quality class 8.8 and higher) can be mounted easier and more economically even when the size of the components cannot be reduced due to their application.

Reduced tension due to settling

The amount of settling after fastening results from the yielding of the components assembled, the number of joints and to a limited extent from the surface roughness of the joints.

Durability under changing load

Two points must be observed in this regard:
a) The amount of changing axial force acting on the bolt
b) The durability of the bolt in connection with the mating nut thread.

Pressure applied to the components

In the contact surface between bolt head or nut and the assembled components neither the tightening force nor the maximum force should lead to surface pressure resulting in creepage.
The surface pressure calculated from the maximum force should not exceed the crushing yield point of the material assembled.

Dispersion of the tensioning force

The tightening factor is used in considering the dimensioning of the bolt to compensate for the difference between the tensioning force actually reached during tightening and the minimum tensioning force required.

Reduction of the tensioning force

Reduction of the tensioning force in the joint or parts of the joint due to the operating force. For instance: when fastening the cover of a pressure vessel the tensioning force must be sufficiently dimensioned to compensate for the operating force resulting from the overpressure inside the vessel, and additionally the required tightening function must be upheld.

Tightening methods

The tightening method influences the required dimension of the bolt, because the bolt must withstand a torque in addition to the axial force. The various tightening methods in particular influence the variance in the tensioning force. It is therefore necessary that the tightening method that was the basis for the dimensioning of the bolt is actually applied.

Basic tightening methods

Torque controlled tightening

The total tightening torque results from the thread tightening torque and the frictional torque acting on bolt head or nut.

- **With tightening factor α_A = 1.4 to 1.6**

Empirical determination of the set tightening torque on original components, for instance bymeasuring the bolt elongation.

- **With tightening factor α_A = 1.6 to 1.8**

Empirical determination of the set tightening torque by estimating the friction coefficient (surface and lubrication conditions).

- **With tightening factor α_A = 1.7 to 2.5**

Adjust the nutsetter to the final torque comprising the set torque and an additional value.

Angle controlled tightening

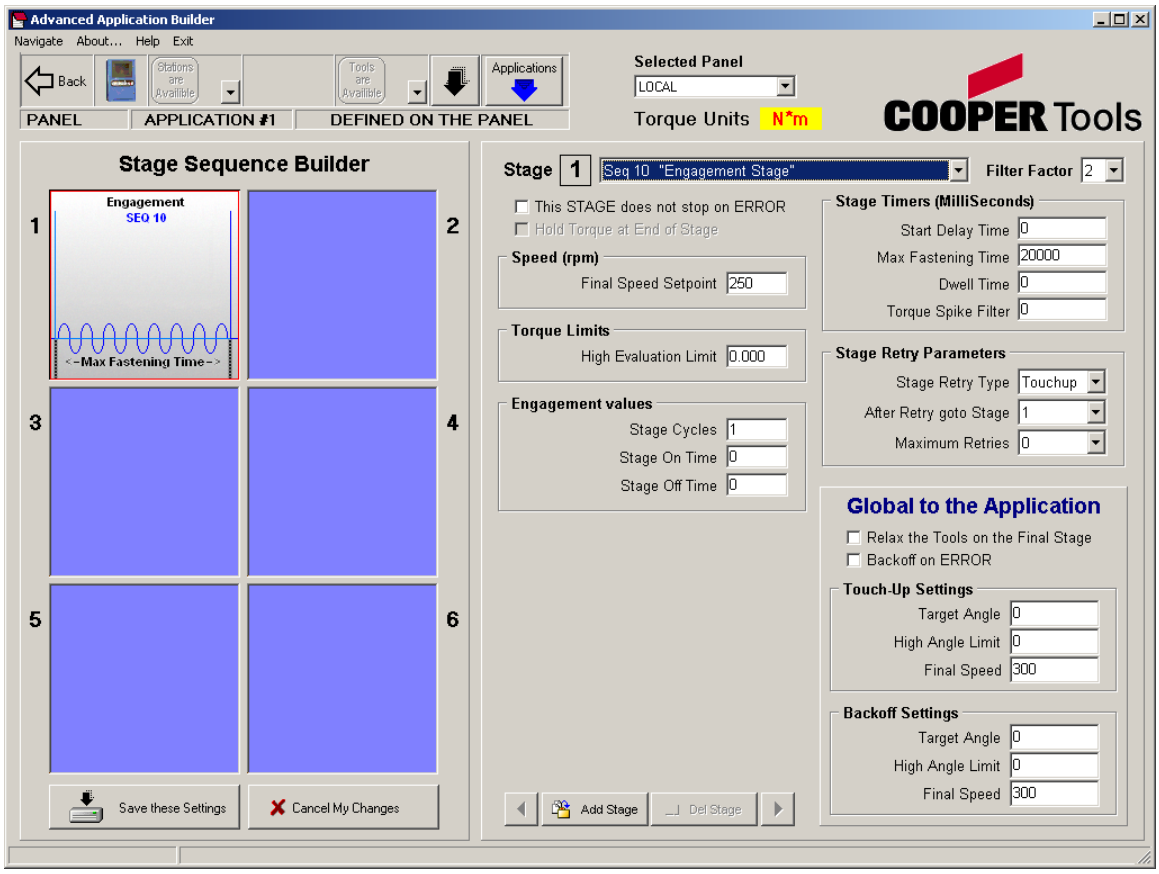
(exceeding the fastener yield point)
Control by rotation angle indirectly is control by measurement of bolt elongation. Since it measures also the plastic deformation of the assembled components this method reaches its best accuracy only when the joint is first tensioned to a defined force and is then further tensioned by a certain angle reaching into the range of plastic deformation of the bolt. Since the yield point is always reached or exceeded, the resulting tensioning will vary simply due to the tolerance of the yield point of the bolts in a given bolt lot.
The highest accuracy is reached when the yield point of the bolt material is exceeded. Plastic deformation of the bolt is thereby tolerated limiting its fitness for reuse, however.
A tightening factor is not required for this method since the bolts are dimensioned to accommodate the minimum tensioning force. This results in optimum exploitation of the bolt material.

Yield point controlled tightening

Yield point controlled tightening methods are based on the fact that the tightening torque does not rise linearly with the rotation angle after the yield point of the bolt material has been reached. The joint is first tightened to an intermediate tensioning force to settle all jointing surfaces. Thereafter the difference ratio is calculated for an adjustable chord length. Tightening is actively terminated as soon as this difference ratio drops to a predefined amount of a maximum value when the bolt material yield point is reached. The tensioning force resulting from tightening of a bolt lot or component lot is largely independent of friction and is only influenced by the variance in the yield point of the bolt material. The plastic elongation that the bolts are subjected to lay in the order of magnitude of the values that define the "Sigma 0.2 limit" of materials with untypical yield point. Therefore, the fitness for reuse of bolts tightened with "yield point control" is practically not impaired.
A tightening factor is not required for this method since the bolts are dimensioned to accommodate the minimum tensioning force. This results in optimum exploitation of the bolt material.
The text in this document is a shortened summary of excerpts from VDI 2230 and is meant for general understanding only.
The tightening methods described on the following pages are fully or partially implemented in the Cooper Power Tools Tork-Trak TM controller and represent the tightening methods discussed above as well as extended and combined versions of these methods.

Engagement Stage
Sequence 10

Turn spindles back and forth to engage the tool socket on the part fastener.



Sequence 10 Engagement Stage

Sequence 10
Setpoint Definition

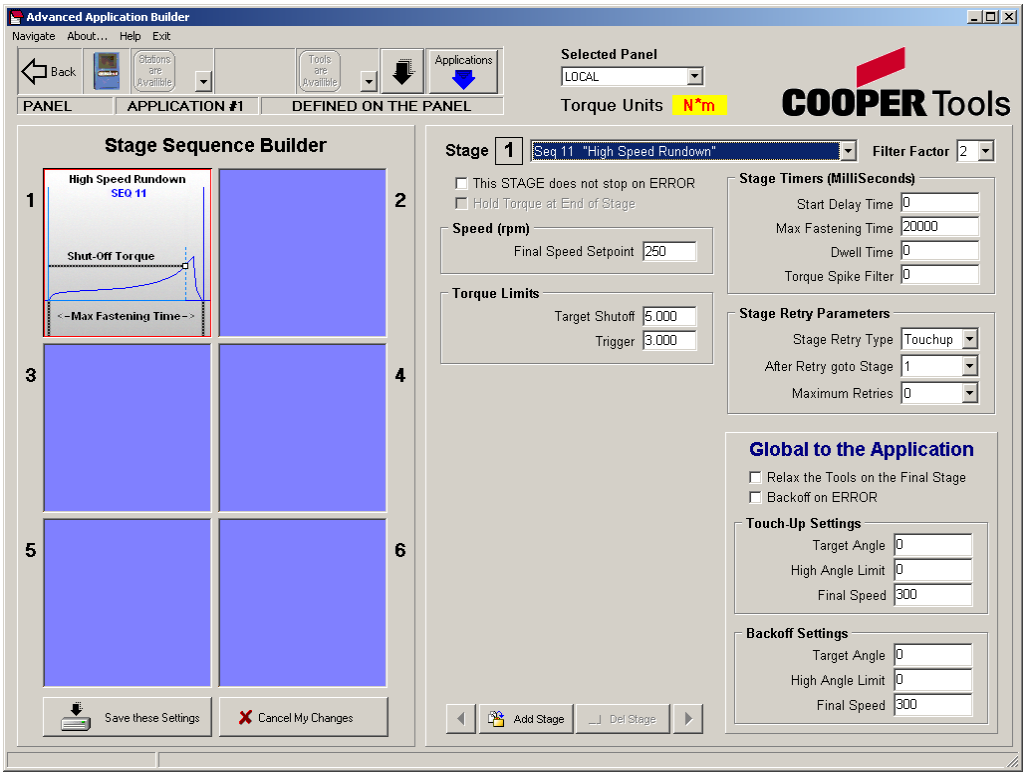
Parameter Value range	Definition
Max evaluation torque 0…Torque cal. Factor	Maximum torque allowed (in both senses of rotation). When it is reached, the sequence is terminated. If this limit value is exceeded, the stage is evaluated NOK (“Tq>” Torque too high).
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value. With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.
Engagement cycles 1…250	Number of engagement cycles. A cycle consists of right-hand rotation (on time), stop (off time), left-hand rotation (on time), stop (off time). This must be observed for programming of the monitoring time for the entire stage.
Engagement On Time 0…60,000	Time during which the spindle is on (in any direction)
Engagement Off Time 0…60,000	Time during which the spindle is off
Speed 1…max speed	Set speed of the spindle’s output shaft

Sequence 10 Notes:

1. The relationship for Sequence 10 Stage time is:
   OCW ON + CW OFF + CCW ON + CCW OFF times cycles = 3000 maximum
2. If High Torque Evaluation Limit is exceeded, the cycle is aborted and rejected.
3. If Stage ON + OFF times 2 times qty stage cycles exceeds the maximaum time, the sequence is not run.
4. If the Max Evaluation Torque is exceeded, the entire cycle is aborted, and the following sequences will not be started.

High Speed Rundown
Sequence 11

The purpose of the High Speed Rundown Strategy is to provide the ability to turn a nut or bolt at an initial high rotational speed prior to reaching snug torque. This is usually stage 1 of a 2 stage rundown strategy. The higher rundown speed reduces process cycle time.
A typical application for this strategy is to combine it with a Torque Control, Angle Monitor fastening strategy in a 2-stage rundown.



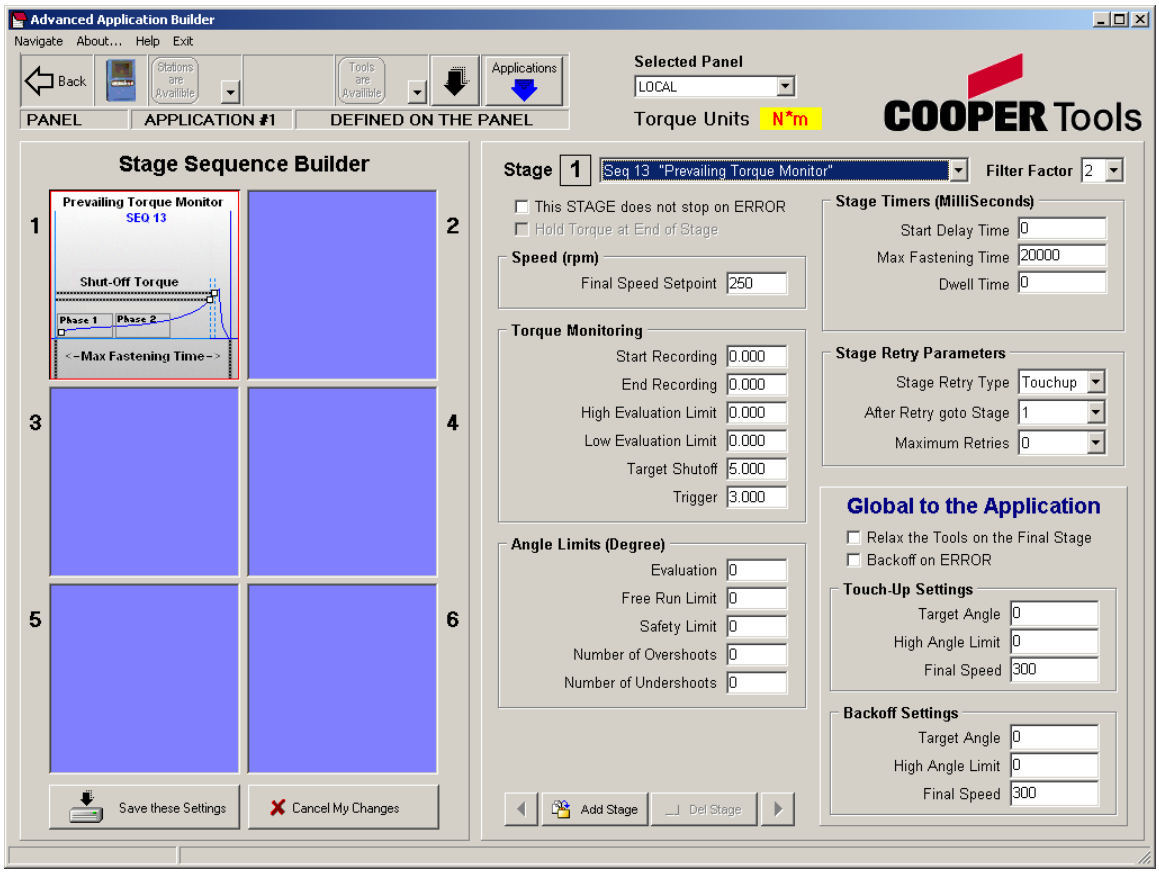
Sequence 11 High Speed Rundown

Sequence 11
Setpoint Definition

Parameter Value Range	Definition
Shut-off torque 0...Torque cal. factor	Torque as target value; when it is reached, the sequence is terminated.
Trigger torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the recording for graphic representation begins.
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.
Speed 1...max speed	Set speed of the spindle´s output shaft

Prevailing Torque Monitor
Sequence 13

Tightening until the fastener´s head makes contact, with torque monitoring, torque-controlled shut-off with subsequent torque evaluation.



Sequence 13 Prevailing Torque Monitor

Sequence 13
Setpoint Definition

Parameter Value Range	Definition
Shut-off torque 0…Torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Trigger torque 0…1.2 x Torque cal. Factor	When this torque is exceeded, the recording for graphic representation begins. If the threshold torque on value is higher than the trigger torque, the recording already beings when the threshold torque on is reached.
Evaluation angle 0…9.999	Range for subsequent evaluation (phase 2) The evaluation angle is the monitored range of the fastening of a fastener prior to its making contact, looking back. The range recorded generally ends when the torque rises above the threshold torque off value, because the fastener's head has made contact. To exclude this rise in torque from the evaluation, an unweighted angle between the evaluation range and the end of the recording is ignored. If the range recorded is smaller than the sum of evaluation angle and unweighted angle, this results in an NOK evaluation of the stage ("FSMW": FRTM: Not enough measured values).
Unweighted angle 0…9,999	Range between evaluation angle and the end of the recording that is not evaluated.
Above limit 0…100	Admissible percentage of deviation from the limit value in the evaluation angle. Across the evaluation angle the torque values are checked for exceeding of the max. torque. If the deviation is more than the admissible percentage, an NOK evaluation for the stage results ("P2OV": FRTM Too much overstep in phase 2). If there are deviations, but less than admissible, this will not lead to an NOK evaluation, but only a warning will be output ("P2M>": FRTM Torque in phase 2 too high).

Sequence 13
Setpoint Definition cont'd

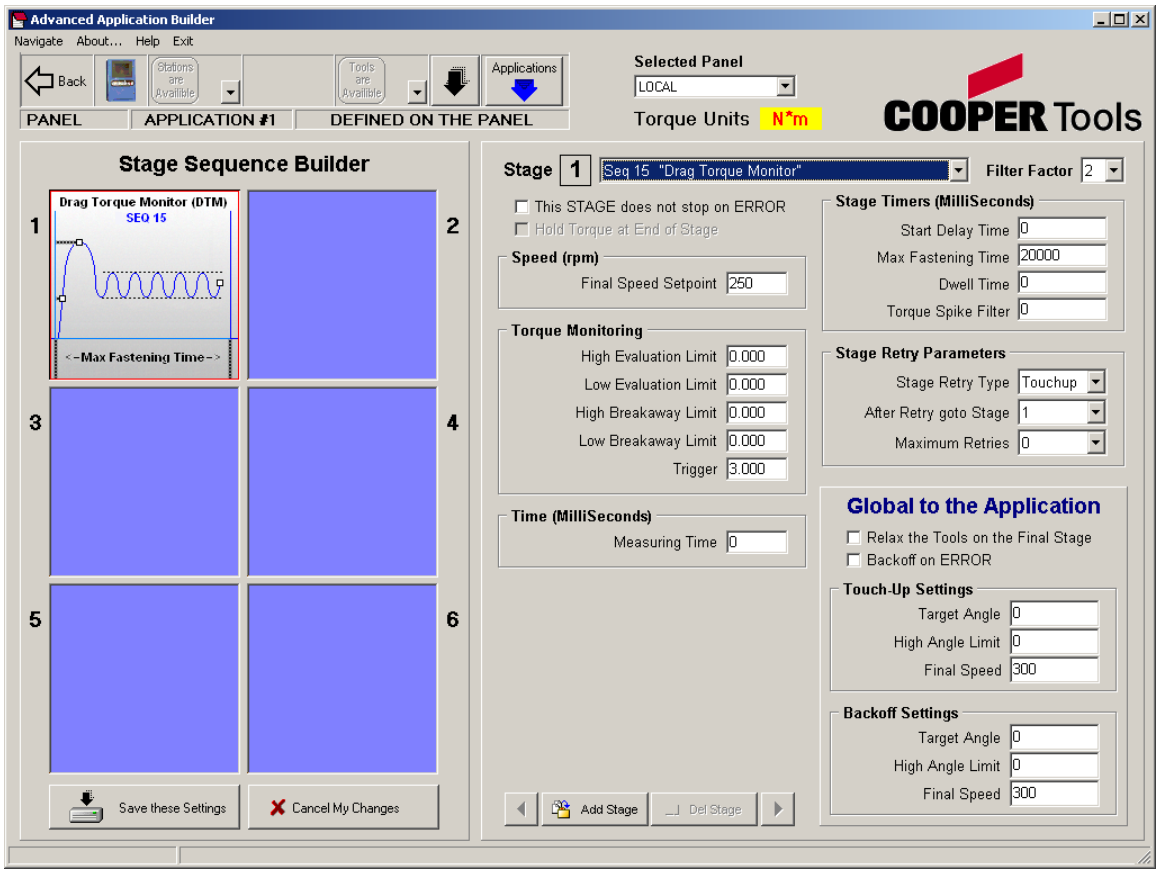
Parameter Value Range	Definition
Below limit 0…100	Admissible percentage of deviation from the limit value in the evaluation angle Across the evaluation angle the torque values are checked for exceeding of the min. evaluation torque. If the deviation is more than the admissible percentage, an NOK evaluation for the stage results (P2UN": FRTM: Too much understep in phase 2). If there are deviations, but less than admissible, this will not lead to an NOK evaluation but only a warning will be output ("P2M>": FRTM Torque in phase 2 too small). If there is too much overstep and understep, the error message "P2OU": FRTM Too much overstep and understep in phase 2 will appear.
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value is recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Sequence 13
Setpoint Definition cont'd

Parameter Value Range	Definition
Max. evaluation torque 0…Torque cal. Factor	High torque limit value during the rundown (phase 1, FRTM angle) and in the subsequently evaluated range (phase 2, evaluation angle) If this limit value is exceeded in phase 1 (FRTM angle), the spindle will shut off immediately and the stage will be evaluated NOK ("P1M>" FRTM: Torque in phase 1 too much).
FRTM angle 0…9,999	Monitored range during fastening (phase 1) beginning with start If the max. Evaluation torque is exceeded in this range (phase 1), the spindle will shut off immediately and the stage will be evaluated NOK ("P1M>"FRTM: Torque in phase 1 too much). This helps trace a misaligned fastener, for instance.
Speed 1…max speed	Set speed of the spindle's output shaft
Joint detection	Special sequence composed of the two sequences 13 and 50. If joint detection is activated, sequence 50 must be programmed as the subsequent sequence.

Drag Torque Monitor
Sequence 15

Time-controlled torque measurement, frictional torque measurement



Sequence 15 Drag Torque Monitor

The sequence “Sequence 15 Drag torque monitor” has been developed as a special process for frictional torque measurements on crank shafts, “DTM = Drag torque monitoring” can also be used for other similar frictional measurements.

Sequence 15
Setpoint Definition

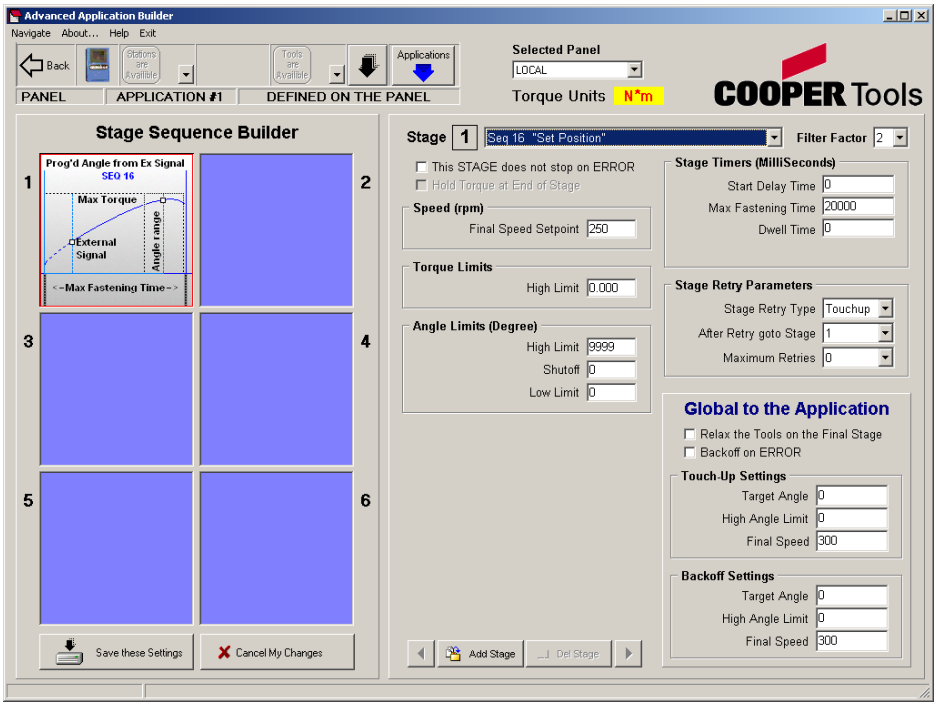
Parameter Range of values	Definition
Trigger torque 0…1.2 x Torque cal. Factor	When this torque is exceeded, the recording for graphic representation begins.
Min. breakaway torque 0…Torque cal. Factor	Low torque limit during start-up (start time). During start-up (start time begins with start) the minimum breakaway torque must be exceeded at least once. Otherwise an NOK will result at the end of the stage (“TqP<”: DTM Breakaway torque not reached). This minimum torque allows finding out whether or not all pistons are installed on a crankshaft turned.
Max. breakaway torque 0…Torque cal. Factor	High limit of the torque during start-up (start time) and the measuring time If the max. breakaway torque is exceeded during start-up (start time begins with start) or during the measuring time (safety shut-off), the process is immediately terminated and an NOK results for the stage (“TqP>”: DTM Breakaway torque too high).
Min. evaluation torque 0…Torque cal. Factor	Low limit of torque in the measuring range (measuring time) If the minimum evaluation torque is not reached during the measuring time, an NOK results (“TqUN”: DTM: Torque too low).

Sequence 15
Setpoint Definition cont'd

Parameter Range of values	Definition
Max. evaluation torque 0…Torque cal. Factor	High limit of torque in the measuring range (measuring time) If the maximum evaluation torque is exceeded during the measuring time, an NOK results ("TqOV": DTM: torque too high).
Start time 0…60,000	Range from start across which the torque is monitored against the breakaway torque limit.
Measuring time 0…60,000	Time during which the torque is monitored against the min/max evaluation torque limit values. The measuring time immediately follows the start time. If the torque min value is not reached, or the max. evaluation torque value is exceeded during the measuring time, an NOK evaluation results for the stage.
Speed 1…max. Speed	Set speed of the spindle's output shaft
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the man value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Set Position
Sequence 16

The purpose of the Set Position Control Fastening Strategy is to provide the ability to turn a pre-programmed angle after receiving an external signal discrete input.
A typical application for this strategy is to tighten a castle hub nut on an axle so that at the completion of the strategy a castle cutout on the nut will line up with the drilled hole in the spindle bolt.



Sequence 16 Set Position

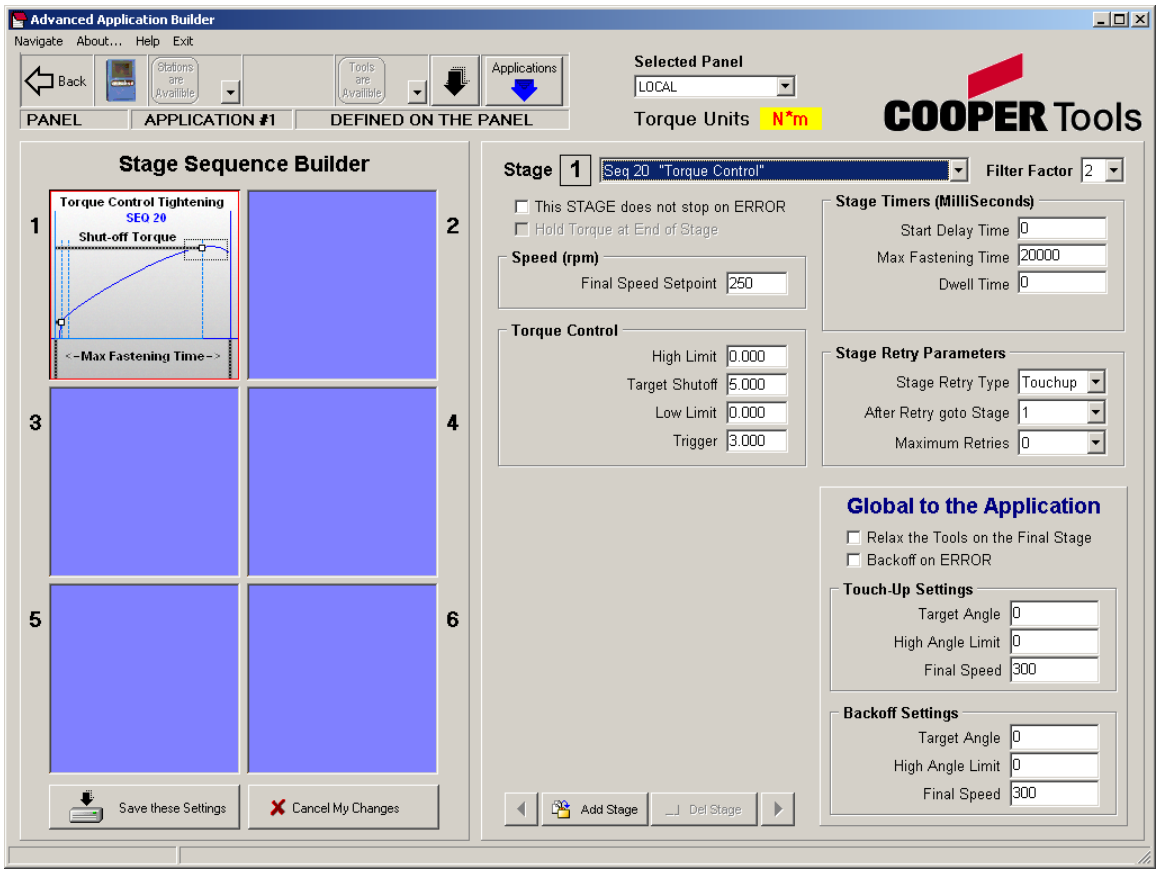
Sequence 16 is usually used in a 2-stage rundown as stage 2. There are five parameters which can be programmed, and these are each described with a range of parameter values in the following table. The external discrete input can be a proximity switch or limit switch sensor which is connected to a physical input. The physical input pinout is user programmable.

Sequence 16
Setpoint Definitions

Parameter and Range of Values	Definition
Shut-off angle 0 to 9,999	Target Angle value. When this value is reached, the rundown is terminated. Angle counting begins when the cycle start input is received.
Angle Low Limit 0 to 9,999	Low limit of angle. If this limit value is not reached, the stage is evaluated NOK.
Angle High Limit 0 to 9,999	High limit of angle. If this limit is exceeded, the rundown is evaluated NOK.
Filtering Factor 1, 2, 4, 8, 16, 32	Number of torque values used to calculate a mean value used in the torque evaluation. A mean value is calculated immediately upon measurement. This factor is equivalent to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The shutoff evaluation is made with these values. A filtering factor of 1 results in no mean value being calculated.
Torque High Limit 0 to 1.2 x Torque calibration factor	High Limit of Final Torque reached. If this limit is exceeded, the stage is evaluated NOK.

Torque Control
Sequence 20

Shut-off torque controlled fastening with torque monitoring



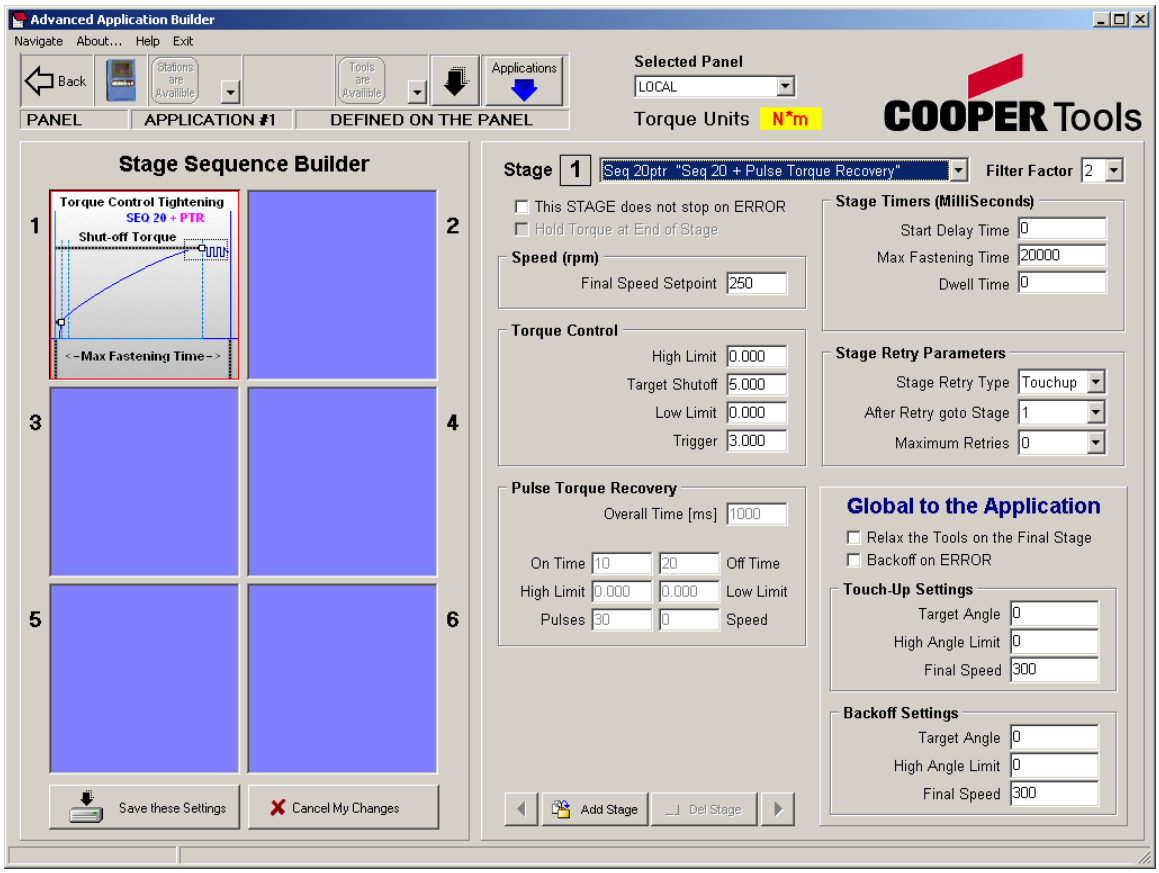
Sequence 20 Torque Control

Sequence 20
Setpoint Definitions

Parameter Range of Values	Definition
Shut-off torque 0…Torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Min. Torque 0…Torque cal. Factor	Low limit of torque reached If this limit value is not reached, NOK for the stage results (“Tq<: Torque too low).
Max. Torque 0…1.2 x Torque cal. Factor	High limit of torque reached If this limit value is exceeded, the stage is evaluated NOK (“Tq>” Torque too high).
Trigger torque 0…1.2 x Torque cal. Factor	When this torque is exceeded, the recording for graphic representation begins.
Speed 1…max speed	Set speed of the spindle’s output shaft
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Torque Control and Pulse Torque Recovery Sequence 20PTR

Shut-off torque controlled fastening with torque monitoring



Sequence 20PTR Torque Control and Pulse Torque Recovery

Sequence 20PTR
Setpoint Definitions

Parameter Range of Values	Definition
Shut-off torque 0…Torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Min. Torque 0…Torque cal. Factor	Low limit of torque reached If this limit value is not reached, NOK for the stage results ("Tq<: Torque too low).
Max. Torque 0…1.2 x Torque cal. Factor	High limit of torque reached If this limit value is exceeded, the stage is evaluated NOK ("Tq>" Torque too high).
Trigger torque 0…1.2 x Torque cal. Factor	When this torque is exceeded, the recording for graphic representation begins.
Speed 1…max speed	Set speed of the spindle's output shaft
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

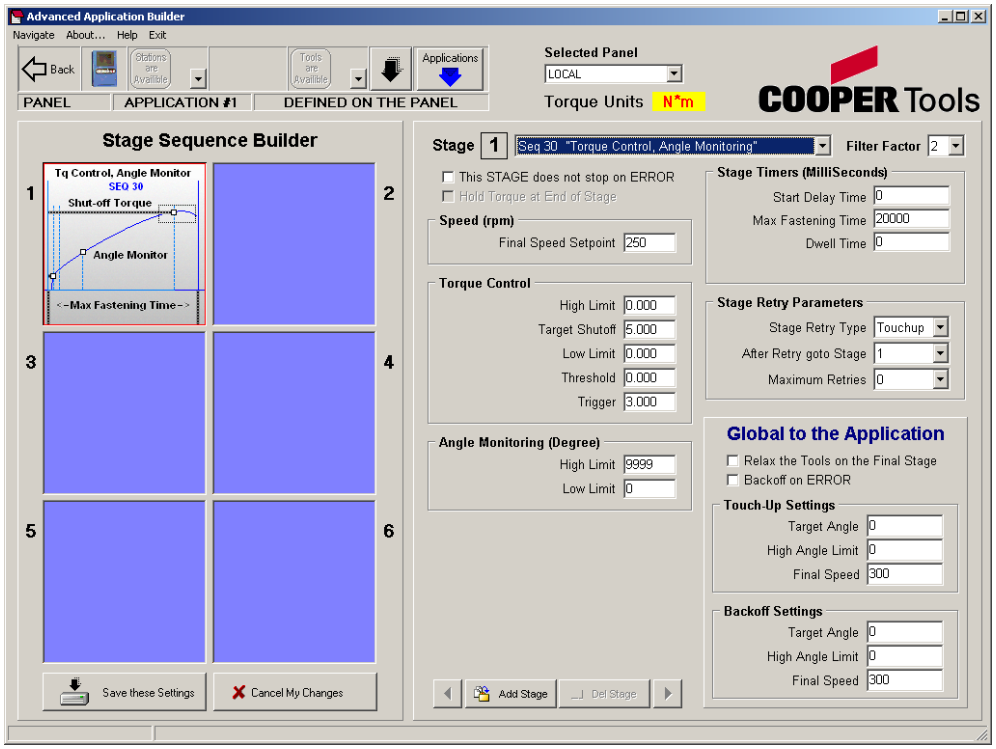
Sequence 20PTR
Setpoint Definitions cont'd

Parameter and Range of Values	Definition
PTR High 0...1.2 x Torque cal factor	This is the upper torque level setting for PTR. It should be programmed to a value less than the Torque High Limit to prevent a Torque High NOK.
PTR Low 0... Torque cal factor	This is the lower torque level setting for PTR. It should be programmed to a value greater than the Torque Low Limit to prevent a Torque Low NOK.
PTR Time 1 ms to 3000 ms	Time duration of the Torque ON plus Torque OFF pulses.
PTR Frequency 25 Hz	Not programmable by the User. Frequency is hard coded to 25 Hz.
PTR Speed	Not programmable by the User. Speed is automatically reduced to a fraction of maximum tool speed.
PTR Number of Pulses 0.25 to 75 pulses	Not directly programmable by the User. Number of pulses is dependant on programmed PTR Time. The number of PTR pulses is approximately 25 times the number of seconds programmed for PTR Time.

Note:
Pulse torque recovery is applied at the conclusion of a fastening rundown, and is used most successfully on joints which are either gasketed or springy sheet metal, where a "makeup torque" is required. If the joint begins to relax immediately following the rundown, Torque Recovery can add a pre-programmed amount of torque for a pre-programmed time duration if the torque drops below a pre-programmed value. This strategy was awarded U.S. Patent 5,094,301.

Torque Control, Angle Monitor
Sequence 30

The purpose of the Torque Control, Angle Monitor Fastening Strategy is to provide the ability to control a fastening rundown to stop after reaching a programmable target torque value. Programmable torque limits above and below target torque are provided for OK or NOK evaluation. In addition, programmable limits for monitoring Angle are provided for OK or NOK evaluation.



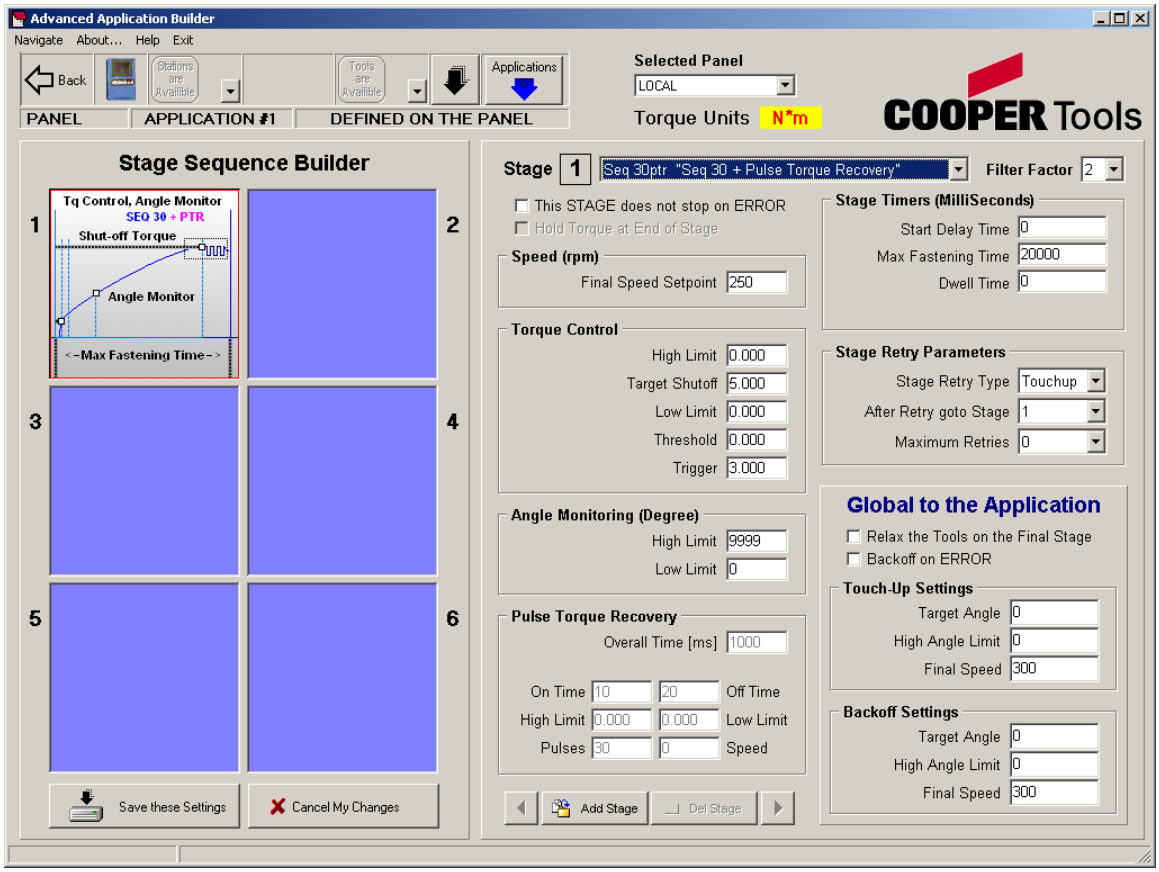
Sequence 30 Torque Control, Angle Monitor

Sequence 30
Set Point Definitions

Parameter and Range of Values	Definition
Shut-off torque 0...Torque cal. factor	Torque as target value; when it is reached, the sequence is terminated.
Min. Torque 0...Torque cal. factor	Low limit of torque reached. If this limit value is not reached, NOK for the stage results (“Tq<”: Torque too low).
Max. Torque 0...1.2 x Torque cal. factor	High limit of torque reached. If this limit value is exceeded, the stage is evaluated NOK (“Tq>” Torque too high).
Max. Angle 0...9,999	High limit of angle reached If this limit is exceeded, the rundown is terminated (safety shut-down) and the stage evaluated NOK (“ANG>”: Angle too high).
Speed 1...max speed	Set speed of the spindle´s output shaft
Trigger torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the recording for graphic representation begins.
Threshold torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the angle counting begins.
Min. angle 0...9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value. With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Torque Control, Angle Monitor and Pulse Torque Recovery Sequence 30PTR

The purpose of the Torque Control, Angle Monitor, Pulse Torque Recovery (PTR) fastening strategy is to provide the ability to control a fastening rundown to reach a programmable target torque value. When shutoff at Target Torque has been achieved, the PTR strategy is executed. Programmable torque limits above and below target torque are provided for OK or NOK evaluation. In addition, programmable limits for monitoring Angle are provided for OK or NOK evaluation. Sequence 30 PTR is exactly the same as Sequence 30, with the addition of Pulse Torque Recovery (PTR). This section will documents Sequence 30 and the Pulse Torque Recovery strategy.
Note that the Sequence 30 PTR screen is different than the Sequence 30 screen. Refer to Figure 3.30PTR-1.



Sequence 30PTR Torque Control, Angle Monitor and Pulse Torque Recovery

Sequence 30PTR
Set Point Definitions

Parameter and Range of Values	Definition
Shut-off torque 0...Torque cal. factor	Torque as target value; when it is reached, the sequence is terminated.
Min. Torque 0...Torque cal. factor	Low limit of torque reached. If this limit value is not reached, NOK for the stage results (“Tq<”: Torque too low).
Max. Torque 0...1.2 x Torque cal. factor	High limit of torque reached. If this limit value is exceeded, the stage is evaluated NOK (“Tq>” Torque too high).
Max. Angle 0...9,999	High limit of angle reached If this limit is exceeded, the rundown is terminated (safety shut-down) and the stage evaluated NOK (“ANG>”: Angle too high).
Speed 1...max speed	Set speed of the spindle output shaft
Trigger torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the recording for graphic representation begins.
Threshold torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the angle counting begins.
Min. angle 0...9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value. With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

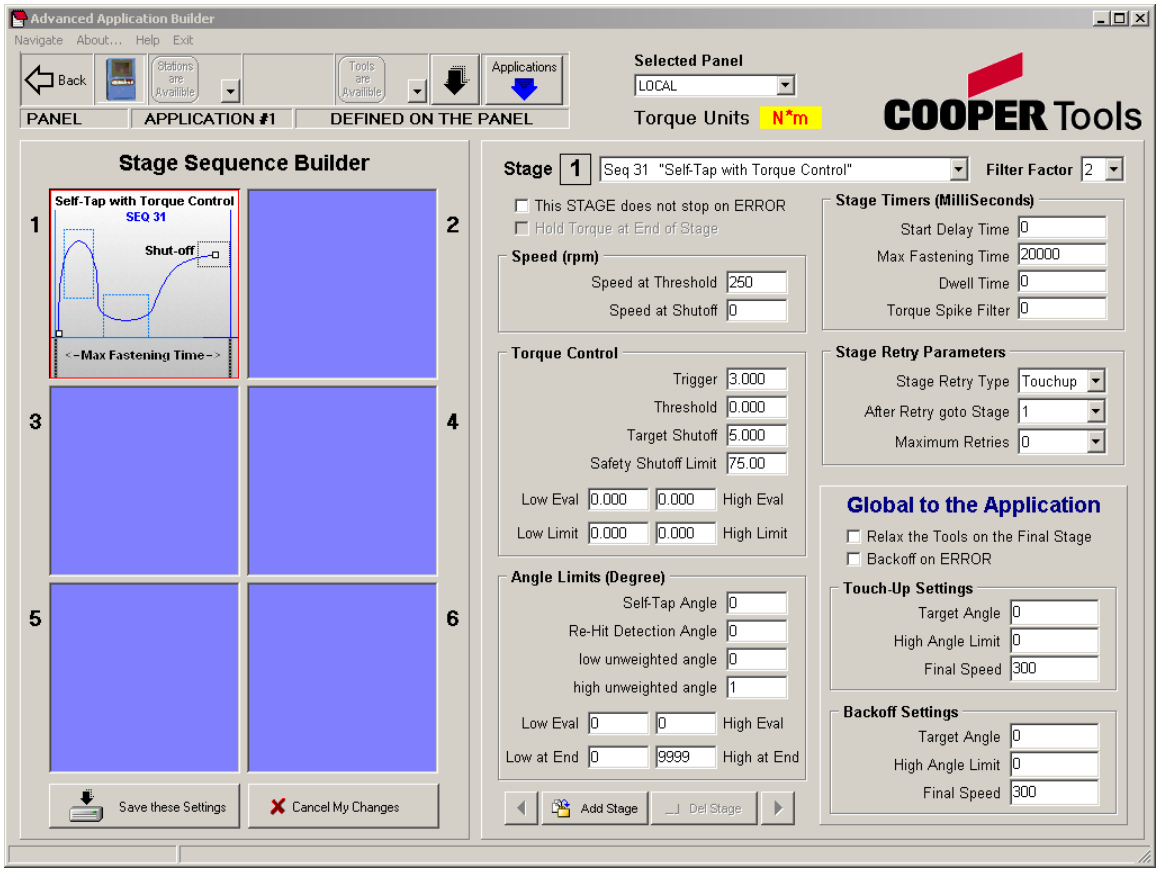
Sequence 30PTR
Set Point Definitions cont'd

Parameter and Range of Values	Definition
PTR High 0...1.2 x Torque cal factor	This is the upper torque level setting for PTR. It should be programmed to a value less than the Torque High Limit to prevent a Torque High NOK.
PTR Low 0... Torque cal factor	This is the lower torque level setting for PTR. It should be programmed to a value greater than the Torque Low Limit to prevent a Torque Low NOK.
PTR Time 1 ms to 3000 ms	Time duration of the Torque ON plus Torque OFF pulses.
PTR Frequency 25 Hz	Not programmable by the User. Frequency is hard coded to 25 Hz.
PTR Speed	Not programmable by the User. Speed is automatically reduced to a fraction of maximum tool speed.
PTR Number of Pulses 0.25 to 75 pulses	Not directly programmable by the User. Number of pulses is dependant on programmed PTR Time. The number of PTR pulses is approximately 25 times the number of seconds programmed for PTR Time.

Note:
Pulse torque recovery is applied at the conclusion of a fastening rundown, and is used most successfully on joints which are either gasketed or springy sheet metal, where a "makeup torque" is required. If the joint begins to relax immediately following the rundown, Torque Recovery can add a pre-programmed amount of torque for a pre-programmed time duration if the torque drops below a pre-programmed value. This strategy was awarded U.S. Patent 5,094,301.

Sequence 31 Self-Tap with Torque Control

Initial monitor of torque for thread cutting followed by torque control for final clamp load.

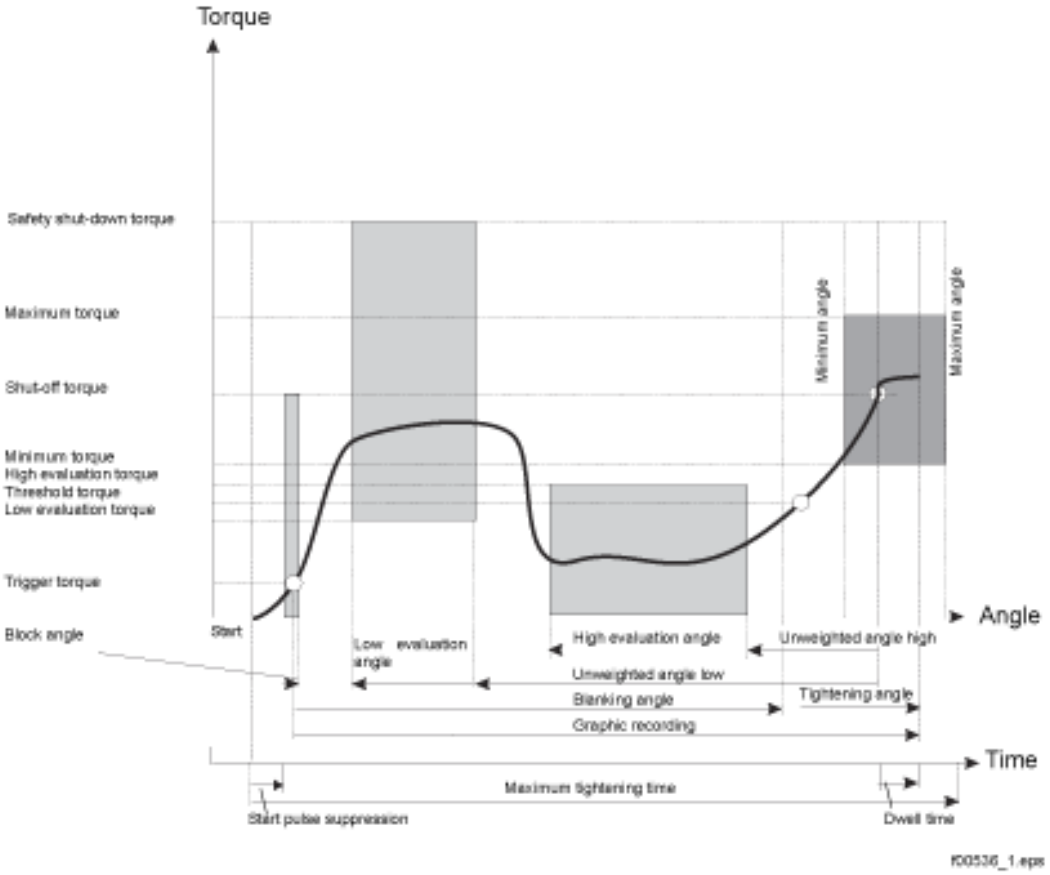


Sequence 31 Self-Tap with Torque Control

Sequence 31: Shut-off torque controlled fastening with torque monitoring and angle monitoring

Sequence 31 is a torque-controlled sequence, which allows the rundown to be evaluated after the shut-off torque has been reached by means of reverse analysis over two monitoring ranges.

Details



The torque curve can be reverse analyzed after rundown is complete. This reverse analysis starts at the shut-off point (the dwell time is not considered) and is achieved using two separate angle ranges.

These angle ranges can be specified separately from one another by setting parameters for the end of the range (= unweighted angle high or low) and the length of the range (= evaluation angle high or low). The two evaluation angles can be in any order and also fully or partially overlap.

The high evaluation angle of the torque curve is checked for overstep of the high evaluation torque and the low evaluation angle of the torque curve is checked for understep of the low evaluation torque. The tightening process is assessed as being NOK if there were oversteps and/or understeps.

The maximum torque is measured within the high evaluation angle, and the lowest torque value within the low evaluation angle and statistical evaluation is carried out.

The evaluation torques can be deactivated by setting the corresponding evaluation angle to zero.

In the **block angle** range, which begins directly after the start pulse suppression, the torque must not exceed the shut-off torque as this will stop the drive. This serves to detect rundowns that are carried out on a tightened bolt. The block angle can be deactivated by setting it to zero.

The torque curve is recorded for the graphic starting from the **trigger torque** (1 torque value per angle degree). These values are also the basis for the reverse analysis. Therefore, the trigger torque must be parametrized so that the torque curve relevant for reverse analysis is always recorded!

An error message with NOK evaluation is generated if there are insufficient torque values for reverse analysis. The torque curve can be output as a graphic.

Parameters can be set for a **blanking angle** that starts when trigger torque is reached. During the blanking angle, detection of the threshold torque and shut-off torque is deactivated and is only reactivated after the blanking angle has finished.

It is permissible for the torque to be higher than the shut-off torque in the blanking angle, but the safety shut-down torque must not be exceeded. The drive is stopped when the safety shut-down torque is exceeded, which applies in the sequence from the end of the impulse suppression time up to the shut-off point. An error message with NOK evaluation is generated. The blanking angle can be deactivated by setting it to zero.

If the block angle and blanking angle overlap, the shut-off torque is considered to be a termination criteria until the end of the block angle.

Angle counting starts when the **threshold torque** is reached if detection of the threshold torque has not been deactivated by the block angle or blanking angle.

Note: If the threshold torque ≤ trigger torque, then angle counting starts when the threshold torque is reached and continues in the blanking angle.

Angle measurement and possibly also redundancy monitoring starts when the drive starts.

After the shut-off torque has caused a shut-down, the torque and/or the corresponding angle are compared to the minimum/maximum torque and the minimum/ maximum angle and evaluated accordingly as OK or NOK. Reverse analysis is also carried out.

The maximum angle, safety shut-down torque and maximum tightening time for the stage are used as a safety shut-down.

Description of parameters

Sequence input value	=	31
Filtering factor	=	Number of measured torque values used for averaging
Trigger torque (Nm)	=	Beginning of storing torque values for the graphic display, reverse analysis and blanking angle
Threshold torque (Nm)	=	Beginning of angle counting; valid outside the blanking angle and block angle
Shut-off torque (Nm)	=	Torque at which the drive is stopped and the dwell time begins; valid outside the blanking angle
Safety shut-down torque (Nm)	=	Monitoring torque valid after start pulse suppression has finished and during the rundown, and the value at which the drive is stopped when it is exceeded
Block angle (deg)	=	Angle, beginning at the end of start pulse suppression, in which the torque must be lower than the shut-off torque
Blanking angle (deg)	=	Angle range starting at the trigger torque, in which the shut-off torque and threshold torque are invalid
Unweighted angle high (deg)	=	End point of the *evaluation angle high*, related to the shut-off point (reverse)
Evaluation angle high (deg)	=	Length of the monitored range for overstep of the high evaluation torque
High evaluation torque (Nm)	=	High torque limit in the *evaluation angle high* that must not be exceeded in reverse analysis
Unweighted angle low (deg)	=	End point of the *evaluation angle low*, related to the shut-off point (reverse)
Evaluation angle low (deg)	=	Length of the monitored range for understep of the low evaluation torque
Low evaluation torque (Nm)	=	Low torque limit in the *evaluation angle low* that must not be understepped in reverse analysis
Maximum torque (Nm)	=	High limit of torque reached
Minimum torque (Nm)	=	Low limit of torque reached
Maximum angle (deg)	=	High limit for angle reached and safety shut-off value
Minimum angle (deg)	=	Low limit of angle reached

Speed 1 (rpm) = Preset speed; maximum speed specified in the range for spindle constants, valid from the beginning of the sequence up to the threshold torque

Speed 2 (rpm) = Speed when the shut-off torque is reached. Must be lower than speed 1.
Cutoff is deactivated when speed 2 = 0 or speed 2 >= speed 1.

Validity of individual parameters

Parameter	Start	End	Evaluation sequence	Suppressed in
Threshold torque	*After start pulse suppression*	*Shut-off point reached*	1	*Block angle, blanking angle*
Safety torque shut-down			2	---
Shut-off torque			3	Block angle, blanking angle
Trigger torque			4	---

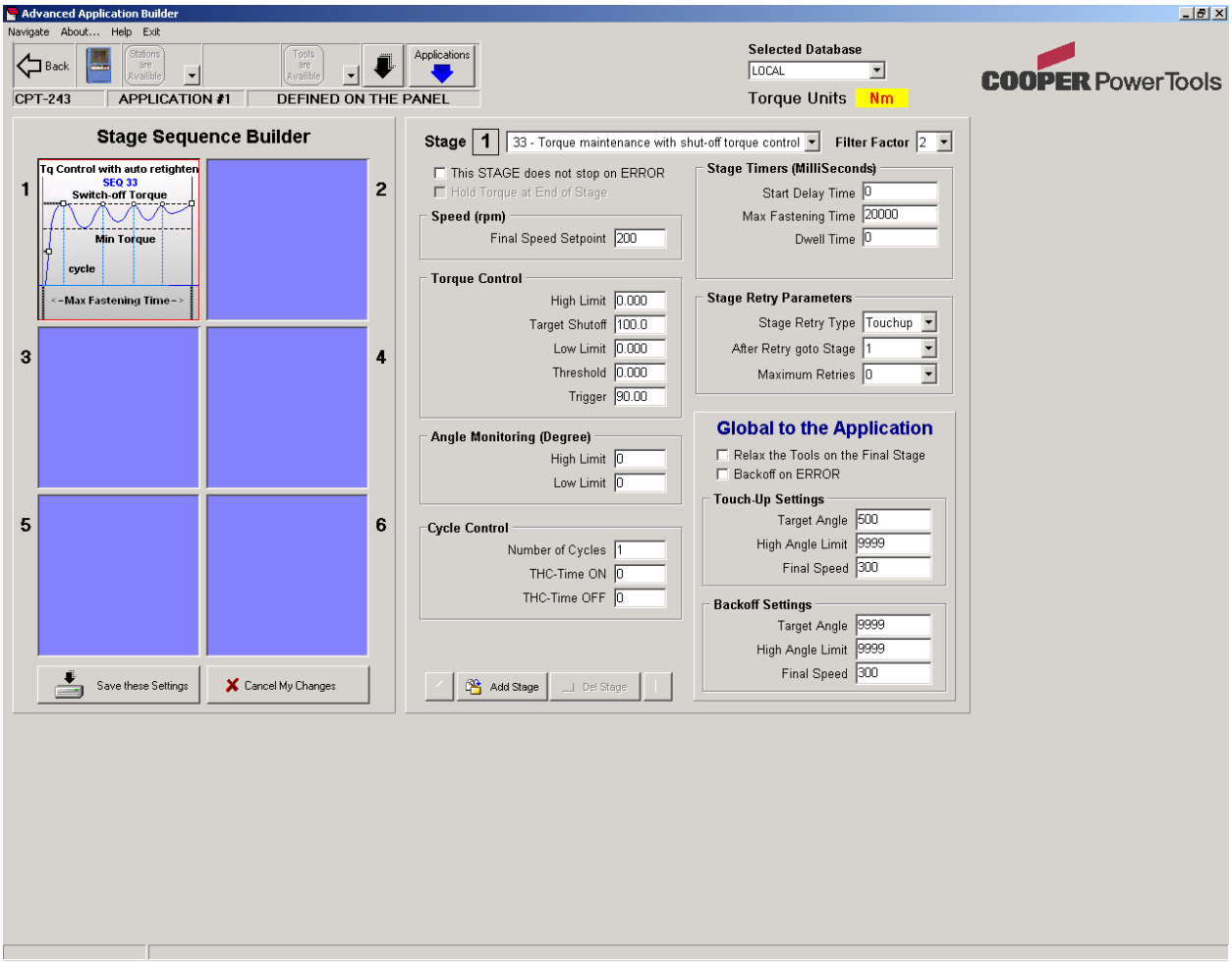
When the values are equal the sequence for evaluation causes a higher priority for evaluation, for instance, of the threshold torque before the trigger torque, i.e. the threshold torque and thus angle counting are activated when the trigger torque and threshold torque have the same numeric values, even if a blanking angle is defined.

Parameter	Start	End	Deactivation
Blanking angle	Trigger torque	After blanking angle degree	Blanking angle = 0
Block angle	After start pulse suppression	After block angle degree	Block angle = 0
Speed 1	At spindle start	1) Shut-off point when speed 2 = 0 2) Threshold torque when speed 2 > 0	---
Speed 2	From threshold torque	Shut-off point	Speed 2 = 0 or Speed 2 ≥ speed 1

Parameters that are analyzed in reverse, i.e. starting from the shut-off point

Parameter	Start	End	Deactivation
High evaluation angle	Shut-off point minus upper unweighted angle	Shut-off point minus upper unweighted angle minus high evaluation angle	High evaluation angle = 0
Upper unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
Upper evaluation torque	*Valid in the high evaluation angle*		High evaluation angle = 0
Low evaluation angle	Shut-off point minus lower unweighted angle	Shut-off point minus lower unweighted angle minus low evaluation angle	Low evaluation angle = 0
Lower unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
Low evaluation torque	*Valid in the low evaluation angle*		Low evaluation angle = 0

Switch-Off Torque Control
Sequence 33



This tightening procedure must be preceded by a pre-clamping Sequence. Sequences 30, 31, 50 51, 63, 73, 75, and 80 show the clamping procedures.

The electronics for each spindle have separate parameters for number of repetitions, on-time, off-time, the switch-off torque, maximum moment, minimum moment, maximum angle, minimum angle, damping factor, trigger moment, the threshold torque and the specified RPM's.

The maximum angle is used as a safety switch-off.

Maximum running time is also specified as an additional safety switch-off.
This affects all spindle drivers of a product group (driving process) in this stage.

The torques and angles of rotation during an operation are measured and processed in a sensing element built into the drivers.

The angles are measured once the threshold moment has been achieved. The driver is operated alternately between rotary motion and maintaining the desired torque. Upon reaching **"Switch-off Torque".** the driver is stopped and the switch-off torque is maintained, preventing mechanical relief of the spindle. During the off-time, the mechanical settling can take place. When the off-time has expired, or if the torque falls below the specified minimum, the spindle starts again with the specified RPM. When the on-time has expired, or if **"Switch-off torque"** has been exceeded, the spindle is stopped again and the switch-off moment is maintained. One cycle consists of one on-time and one off-time. The number of cycles equals the number of specified repetitions.

During the run-down time, the caster angle and peak torque are measured. An automatic, slow and controlled relief of the spindle takes place during the specified run-down time, until torque falls below the specified threshold.

The tightening values of the bolt and a reading of the fastened joint are sent to the value analyzer.

This Sequence can display the values in tabular form on the monitor and / or output to a printer, as well as transmit this information to other network clients.

Once a spindle reaches the specified trigger moment, the rotation angle is recorded and can be displayed and evaluated via the graphic function.

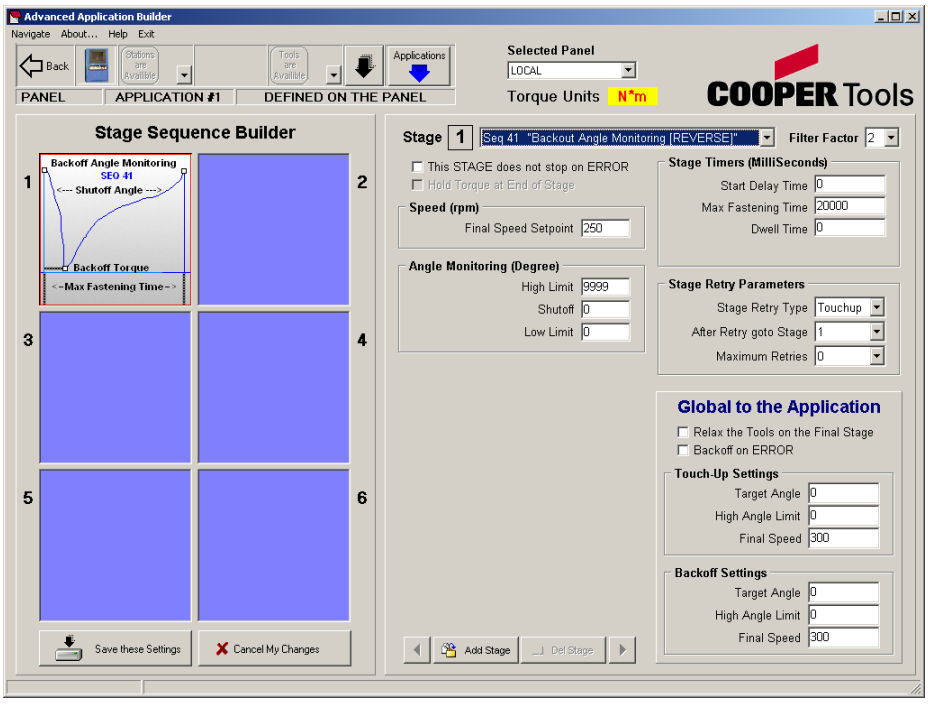
The following parameters can be input to the driver electronics:

Diagram input value:	33
Switch-off torque (Nm)	Stage switch-off torque
Maximum torque (Nm):	Maximum torque, upper limit of achieved torque
Minimum torque (Nm)	Minimum torque, lower limit of achieved torque
Maximum angle (grd):	Maximum angle, upper limit of achieved angle and safety switch-off torque
Minimum angle (grd):	Minimum angle, lower limit of achieved angle

Threshold torque (Nm):	Threshold torque, start of angle counter
Threshold moment (Nm)	Trigger moment, start of value recording for graphic display
Number of repetitions:	Number of repetitions of THC on-time and THC off-time
THC on-time (ms):	The spindle remains switch-on for the duration of this period, as long as the switch-off torque has not been achieved
THC off-time (ms):	The spindle remains in hold mode as long as the minimum torque is maintained
Damping factor	Damping factor, number of measured values based on averaging applied to damping
RPM	RPM selection; in the range of specified maximum RPM's in the spindle constants

Backoff Angle Monitoring
Sequence 41

Shut-off angle controlled backoff with backoff angle monitoring.



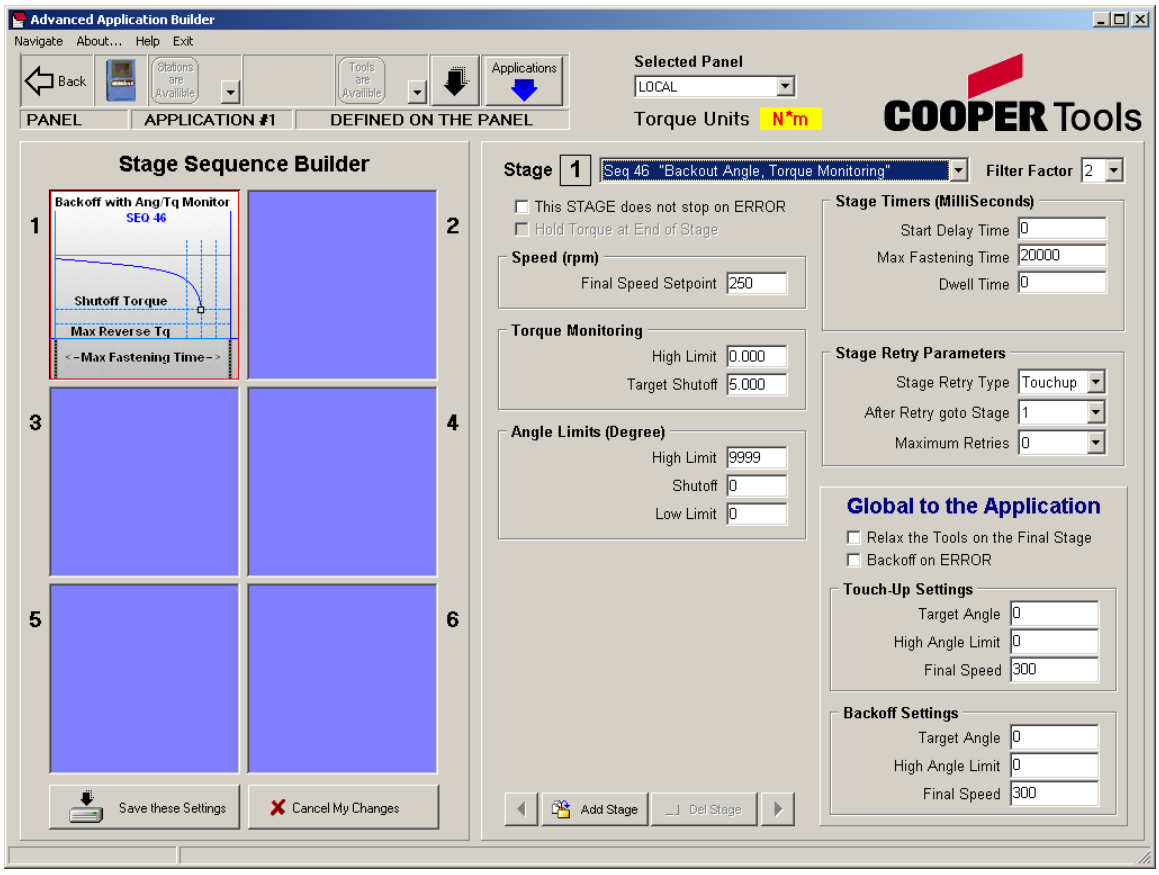
Sequence 41 Backoff Angle Monitoring

Sequence 41
Set Point Definitions

Parameter Range of values	Definition
Shut-off angle 0…9,999	Angle as target value; when it is reached, the rundown is terminated. Angle counting begins with the spindle start.
Min. angle 0…9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Max. angle 0…9,999	High limit of angle reached If this limit value is exceeded, the stage is evaluated NOK (“ANG>” angle too high).
Speed 1…max speed	Set speed of the spindle’s output shaft
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Backoff Angle and Torque Monitoring
Sequence 46

Shut-off angle controlled backoff with angle and torque monitoring



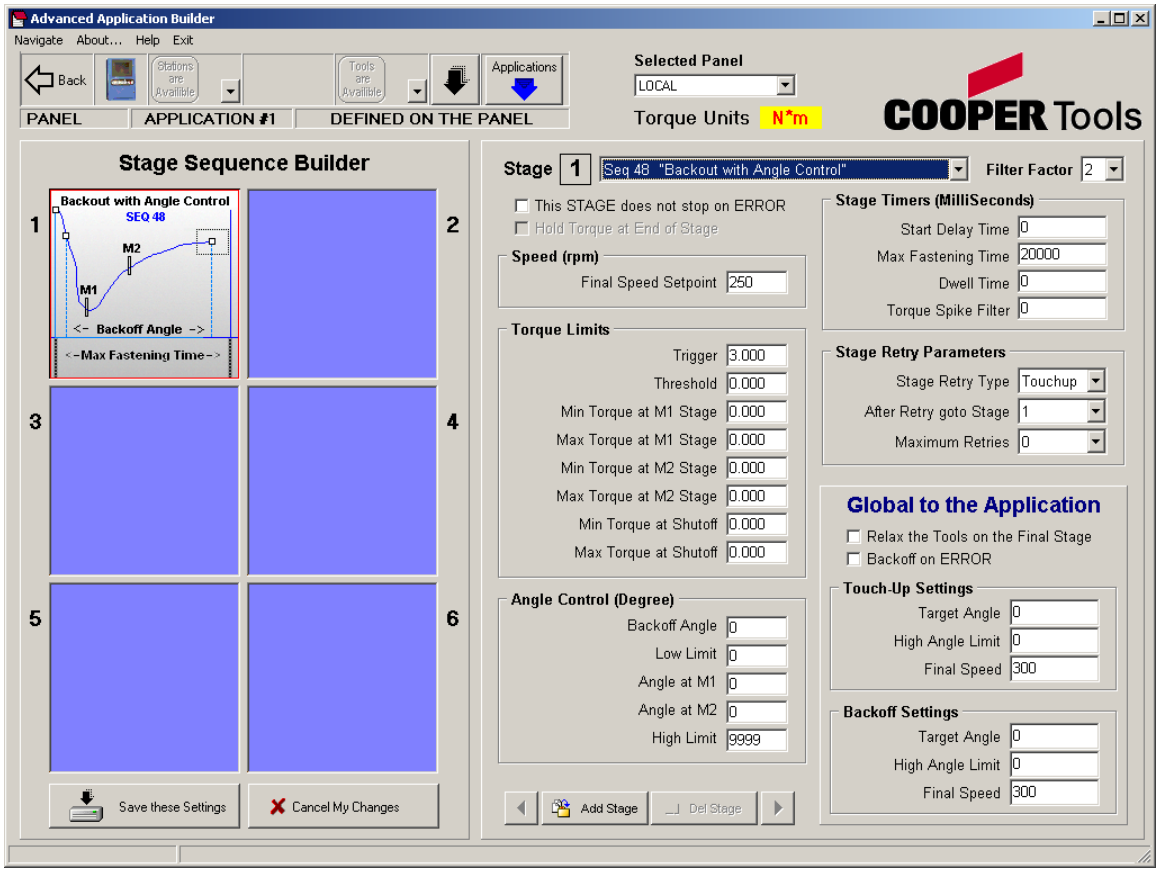
Sequence 46 Backoff Angle and Torque Monitoring

Sequence 46
Set Point Definitions

Parameter Range of values	Definition
Shut-off angle 0…9,999	Angle as target value; when it is reached, the rundown is terminated. Angle counting begins with the spindle start.
Shut-off torque 0…Torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Max. Torque 0…1.2 x Torque cal. Factor	High limit of torque reached. If this limit value is exceeded, the stage is evaluated NOK (“Tq>” Torque too high).
Min. Angle 0…9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Max. Angle 0…9,999	High limit of angle reached If this limit is exceeded, the rundown is terminated (safety shut-down) and the stage evaluated NOK (“ANG>”: Angle too high).
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Backoff Angle Control with Torque Monitoring
Sequence 48

Controlled Angle reverse strategy with 2 Torque Monitoring Points.

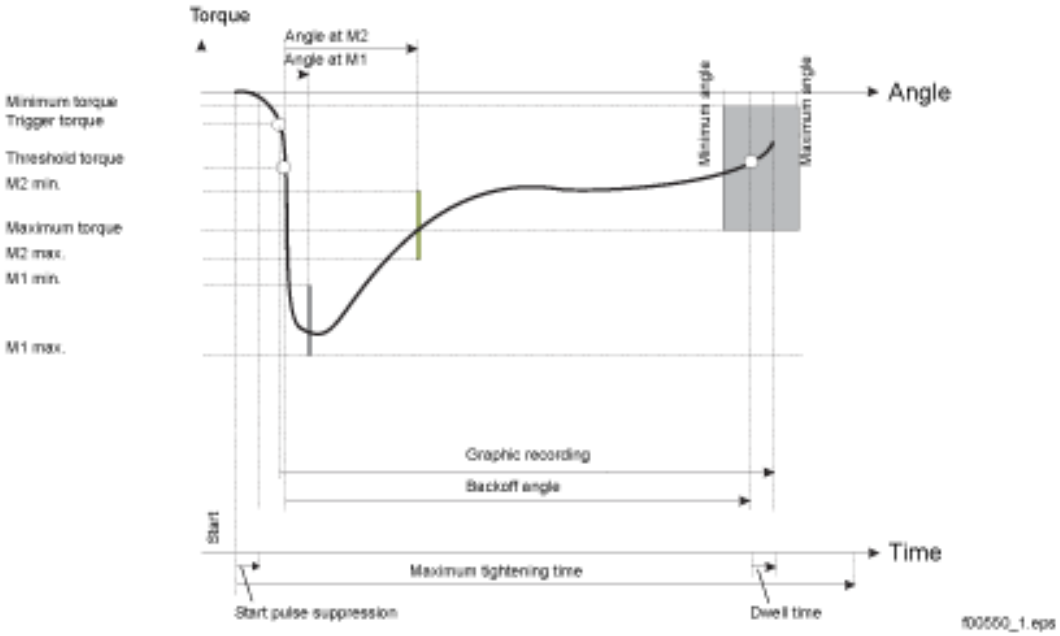


Sequence 48 Backoff Angle Control with Torque Monitoring

Sequence 48: Shut-off angle controlled fastening with backoff angle and residual torque monitoring

Sequence 48 is an angle-controlled sequence in which the two points can be defined at both of which a minimum and a maximum torque value must not be understepped or overstepped.

Details



One check is carried out at each of the two points M1 and M2 in order to ascertain whether M1 min., M1 max. and M2 min., M2 max. torque limits are understepped or overstepped. Points M1 and M2 are specified by the angle at M1 and angle at M2 from the threshold torque.

Should the torque at these points not lay within the corresponding min/max limits the drive is stopped and the rundown data is evaluated as NOK.

The time sequence for the two points is not specified, i.e. M1 can lay to the left or right of M2 or at M2. The torque check in the points M1 and M2 can be deactivated individually by setting the angle at M1 or M2 to zero.

M1 max. also serves as a safety shut-down torque in the whole sequence. When M1 max. is exceeded the drive is stopped and the rundown data is evaluated as NOK.

Note: The safety shut-down torque M1 max. also remains active when M1 has been deactivated by setting the M1 angle to zero!

The torques at M1 and M2 as well as the maximum torques in the rundown are measured and the results are included in the statistical evaluation.

Angle counting starts from the threshold torque.

After switch-off due to the backoff angle having been reached, the minimum/maximum torque and the minimum/maximum angle are used to evaluate the result as OK or NOK.

Parameters can be set for a maximum time, a start pulse suppression time and a dwell time.

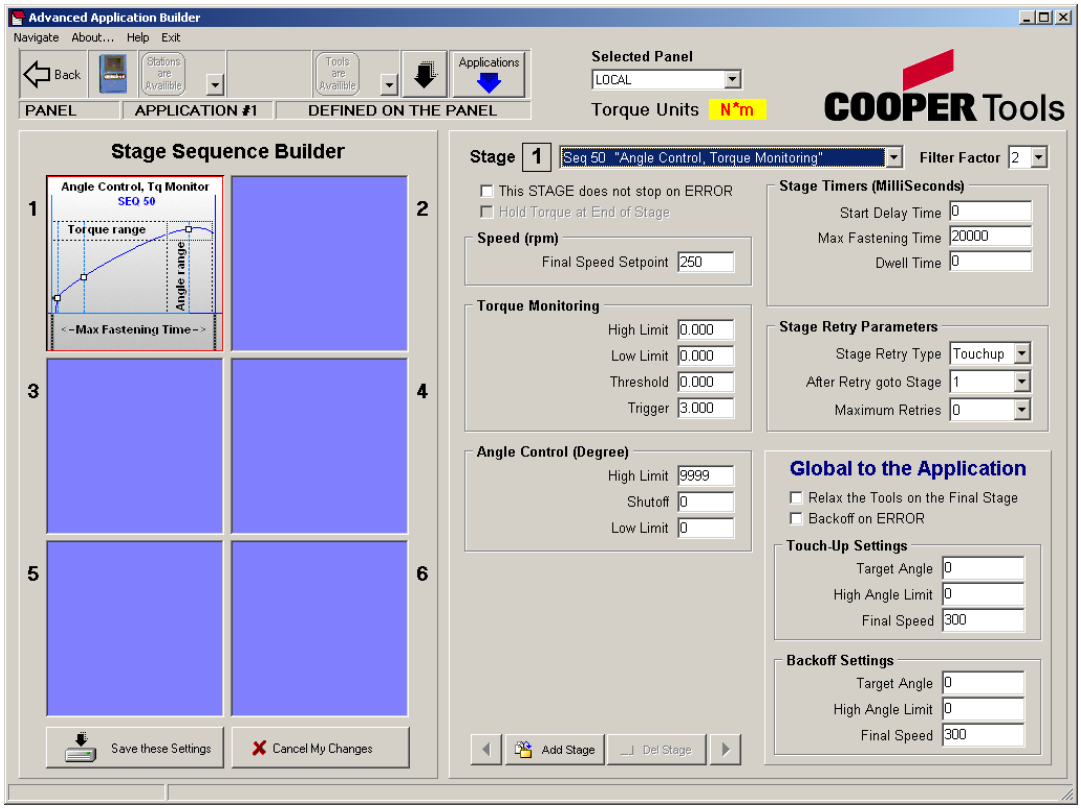
When the trigger torque is reached, recording of the torque curve starts and the curve can be viewed and evaluated in a graphic.

Description of parameters

Sequence input value:		48
Filtering factor	=	Number of measured values used for averaging
Trigger torque (Nm)	=	Start of storing the torque value for the graphical view
Threshold torque (Nm)	=	Beginning of angle counting
Backoff angle (deg)	=	Angle at which the drive is stopped and the dwell time begins
Angle at M1 (deg)	=	Angle, at which the torque is checked at a position between M1 max. and M1 min.; the drive is stopped when the position lays outside of the range M1 min. to M1 max.
M1 max. (Nm)	=	Maximum torque allowed in the sequence
M1 min. (Nm)		Minimum torque allowed at M1
Angle at M2 (deg)	=	Angle, at which the torque is checked at a position between M2 max. and M2 min.; the drive is stopped when the position lays outside of the range M2 min. to M2 max.
M2 max. (Nm)	=	Maximum torque allowed at M2
M2 min. (Nm)	=	Minimum torque allowed at M2
Maximum torque (Nm)	=	High limit of torque reached in the shut-off point
Minimum torque (Nm)	=	Low limit of torque reached in the shut-off point
Maximum angle (deg)	=	High limit of angle reached in the shut-off point and shut-off value
Minimum angle (deg)	=	Low limit of angle reached in the shut-off point
Speed (rpm)	=	Preset speed; within the maximum speed range specified in the range for spindle constants

Angle Control, Torque Monitor
Sequence 50

The purpose of the Angle Control, Torque Monitor Fastening Strategy is to provide the ability to control a fastening rundown to stop after reaching a programmable target angle value. Programmable angle limits above and below target angle are provided for OK or NOK evaluation. In addition, programmable limits for monitoring Torque are provided for OK or NOK evaluation.



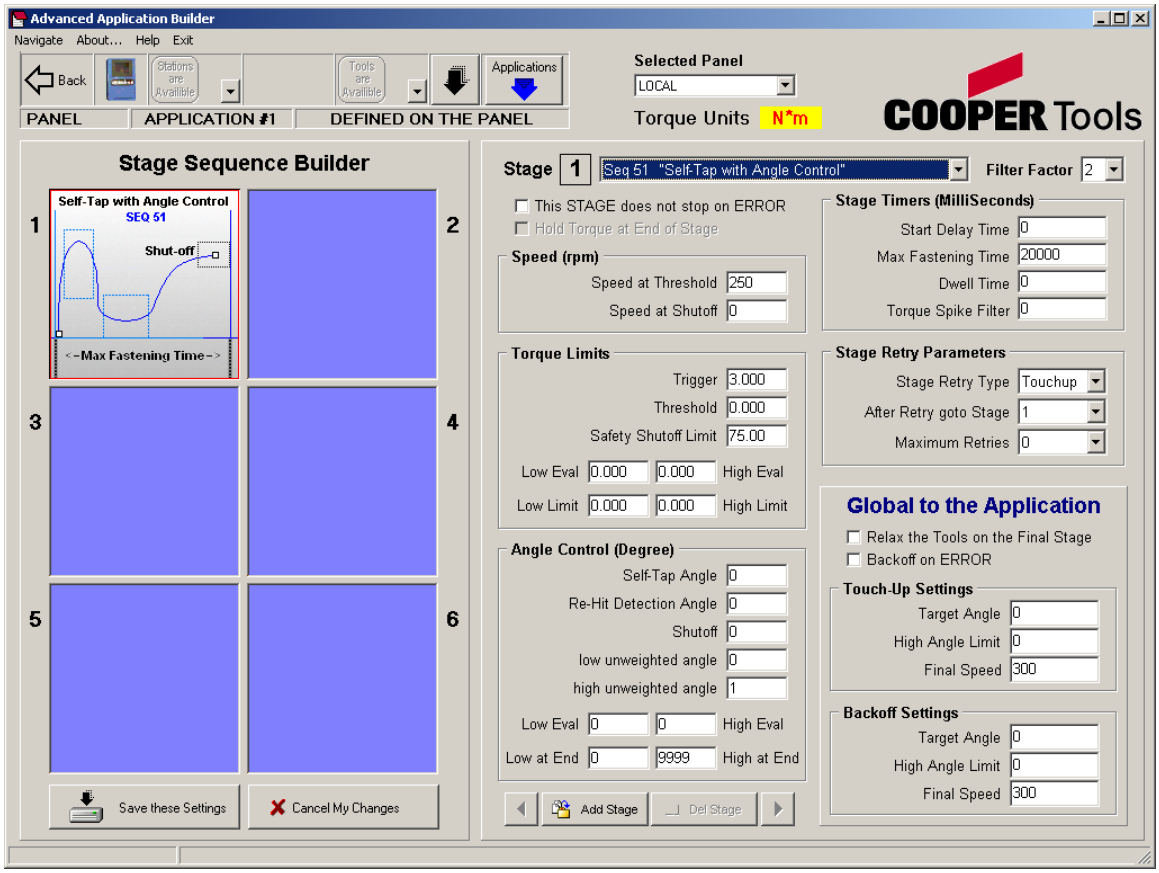
Sequence 50 Angle Control, Torque Monitor

Sequence 50
Set Point Definitions

Parameter Range of Values	Definition
Shut-off angle 0...9,999	Angle as target value; when it is reached, the rundown is terminated.
Min. Angle 0...9,999	Low limit of angle reached. If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Max. Angle 0...9,999	High limit of angle reached. If this limit value is exceeded, the stage is evaluated NOK (“ANG>” Angle too high).
Max. Torque 0...1.2 x Torque cal. Factor	High limit of torque reached If this limit is exceeded, the rundown is terminated (safety shut-down) and the stage evaluated NOK (“Tq>”: Torque too high).
Speed 1...max speed	Set speed of the spindle´s output shaft
Trigger torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the recording for graphic representation (O'Scope) begins.
Threshold torque 0...1.2 x Torque cal. factor	When this torque is exceeded, the angle counting begins.
Min. torque 0...9,999	Low limit of torque reached If this limit value is not reached, an NOK for the stage results (“Tq<”: Torque too low).
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value. With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Sequence 51

Initial monitor of torque for thread cutting followed by angle control for final clamp load.

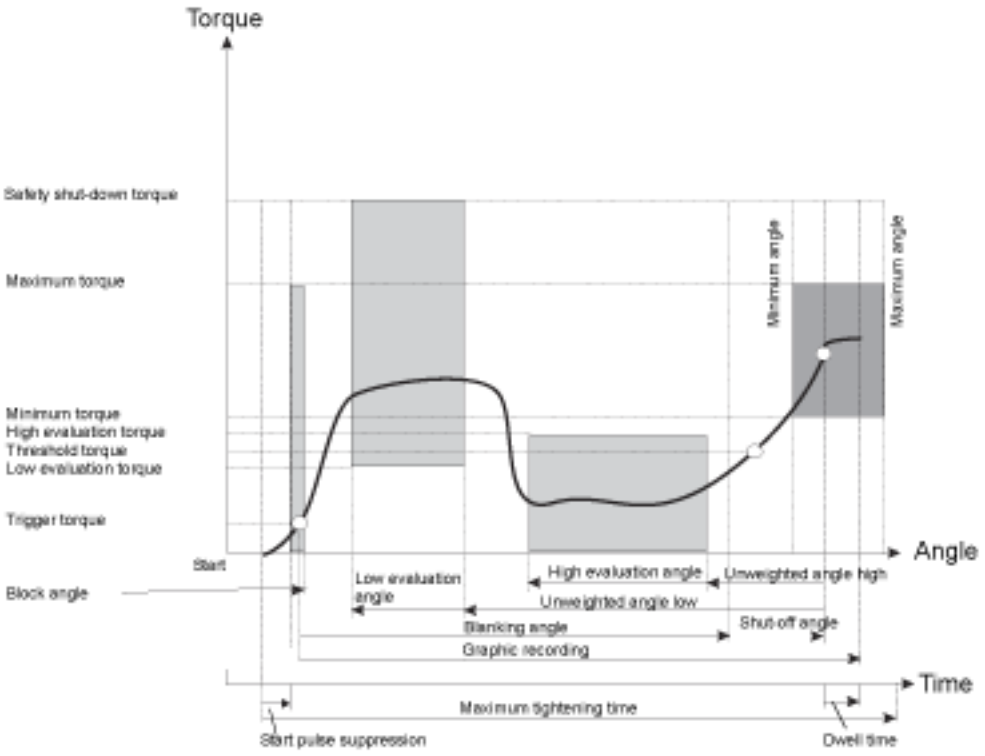


Sequence 51 Torque Control (Self-Tap) with Angle Control

Sequence 51: Shut-off angle controlled fastening with angle and torque monitoring

Sequence 51 is an angle-controlled sequence, which allows the rundown to be evaluated after the shut-off angle has been reached by means of reverse analysis over two monitoring ranges. Additionally, the monitoring torque can be changed by an angle range during the rundown.

Details



The torque curve can be reverse analyzed after rundown is complete. This reverse analysis starts at the shut-off point (the dwell time is not considered) and is achieved using two separate angle ranges.

These angle ranges can be specified separately from one another by setting parameters for the end of the range (= unweighted angle high or low) and the length of the range (= evaluation angle high or low). The two evaluation angles can be in any order and also fully or partially overlap.

The high evaluation angle of the torque curve is checked for overstep of the **evaluation torque** and the low evaluation angle of the torque curve is checked for understep of the low evaluation torque. The tightening process is assessed as being NOK if there were oversteps and/or understeps.

The maximum torque is measured within the high evaluation angle, and the lowest torque value within the low evaluation angle and statistical evaluation is carried out.

The evaluation torques can be deactivated by setting the corresponding evaluation angle to zero.

In the **block angle** range, which begins directly after the start pulse suppression, the torque must not exceed the maximum torque as this will stop the drive. This serves to detect rundowns that are carried out on a tightened bolt. The block angle can be deactivated by setting it to zero.

The torque curve is recorded for the graphic starting from the **trigger torque** (1 torque value per angle degree). These values are also the basis for the reverse analysis. Therefore, the trigger torque must be parametrized so that the torque curve relevant for reverse analysis is always recorded!

An error message with NOK evaluation is generated if there are insufficient torque values for reverse analysis. The torque curve can be output as a graphic.

Parameters can be set for a **blanking angle** that starts when trigger torque is reached. During the blanking angle, detection of the threshold torque and maximum torque is deactivated and is only reactivated after the blanking angle has finished.

It is permissible for the torque to be higher than the maximum torque in the blanking angle, but the safety shut-down torque must not be exceeded. The drive is stopped when the safety shut-down torque is exceeded, which applies in the sequence from the end of the start pulse suppression time up to the shut-off point. An error message with NOK evaluation is generated. The blanking angle can be deactivated by setting it to zero.

If the block angle and blanking angle overlap, the maximum torque is considered to be a termination criteria until the end of the block angle.

Angle counting starts when the **threshold torque** is reached if detection of the threshold torque has not been deactivated by the block angle or blanking angle.

Note: If the threshold torque ≤ trigger torque, then angle counting starts when the threshold torque is reached and continues in the blanking angle. Angle measurement and possibly also redundancy monitoring starts when the drive starts.

After the shut-off torque has caused a shut-down, the corresponding angle and/or the torque are compared to the minimum/maximum angle and the minimum/ maximum torque and evaluated accordingly as OK or NOK. Reverse analysis is also carried out.

The maximum angle, maximum torque, safety shut-down torque and maximum tightening time for the stage are used as a safety shut-down.

Description of parameters

Sequence input value	=	51
Filtering factor	=	Number of measured torque values used for averaging
Trigger torque (Nm)	=	Beginning of storing torque values for the graphic display, reverse analysis and blanking angle
Threshold torque (Nm)	=	Beginning of angle counting; valid outside the blanking angle and block angle
Safety shut-down torque (Nm)	=	Monitoring torque valid after start pulse suppression has finished and during the rundown, and the value at which the drive is stopped when it is exceeded
Shut-off angle (deg)	=	Angle at which the drive is stopped and the dwell time begins;
Block angle (deg)	=	Angle, beginning at the end of start pulse suppression, in which the torque must be lower than the maximum torque
Blanking angle (deg)	=	Angle range starting at the trigger torque, in which the maximum torque and threshold torque are invalid
Unweighted angle high (deg)	=	End point of the *evaluation angle high*, related to the shut-off point (reverse)
Evaluation angle high (deg)	=	Length of the monitored range for overstep of the high evaluation torque
High evaluation torque (Nm)	=	High torque limit in the *evaluation angle high* that must not be exceeded in reverse analysis
Unweighted angle low (deg)	=	End point of the *evaluation angle low*, related to the shut-off point (reverse)
Evaluation angle low (deg)	=	Length of the monitored range for understep of the low evaluation torque
Low evaluation torque (Nm)	=	Low torque limit in the *evaluation angle low* that must not be understepped in reverse analysis
Maximum torque (Nm)	=	High limit of torque reached
Minimum torque (Nm)	=	Low limit of torque reached
Maximum angle (deg)	=	High limit for angle reached and safety shut-off value
Minimum angle (deg)	=	Low limit of angle reached

Speed 1 (rpm)	=	Preset speed; maximum speed specified in the range for spindle constants, valid from the beginning of the sequence up to the threshold torque
Speed 2 (rpm[1])	=	Speed when the maximum torque is reached. Must be lower than speed 1. Cutoff is deactivated when speed 2 = 0 or speed 2 ≥ speed 1.

1) The maximum torque is normally not reached; the torque shut-off value is lower than the maximum torque, so the speed will not fully cut off to speed 2.

Validity of individual parameters

Parameter	Start	End	Sequence for evaluation	Suppressed in
Threshold torque	After start pulse suppression	Shut-off point reached	1	Block angle, blanking angle
Safety torque shut-down			2	---
Shut-off angle			3	---
Trigger torque			4	---

When the values are equal the sequence for evaluation causes a higher priority for evaluation, for instance, of the threshold torque before the trigger torque, i.e. the threshold torque and thus angle counting are activated when the trigger torque and threshold torque have the same numeric values, even if a blanking angle is defined.

Parameter	Start	End	Deactivation
Blanking angle	Trigger torque	After blanking angle degree	Blanking angle = 0
Block angle	After start pulse suppression	After block angle degree	Block angle = 0
Speed 1	At spindle start	1) Shut-off point when speed 2 = 0 2) Threshold torque when speed 2 > 0	---
Speed 2	From threshold torque	Shut-off point	Speed 2 = 0 or speed 2 ≥ speed 1

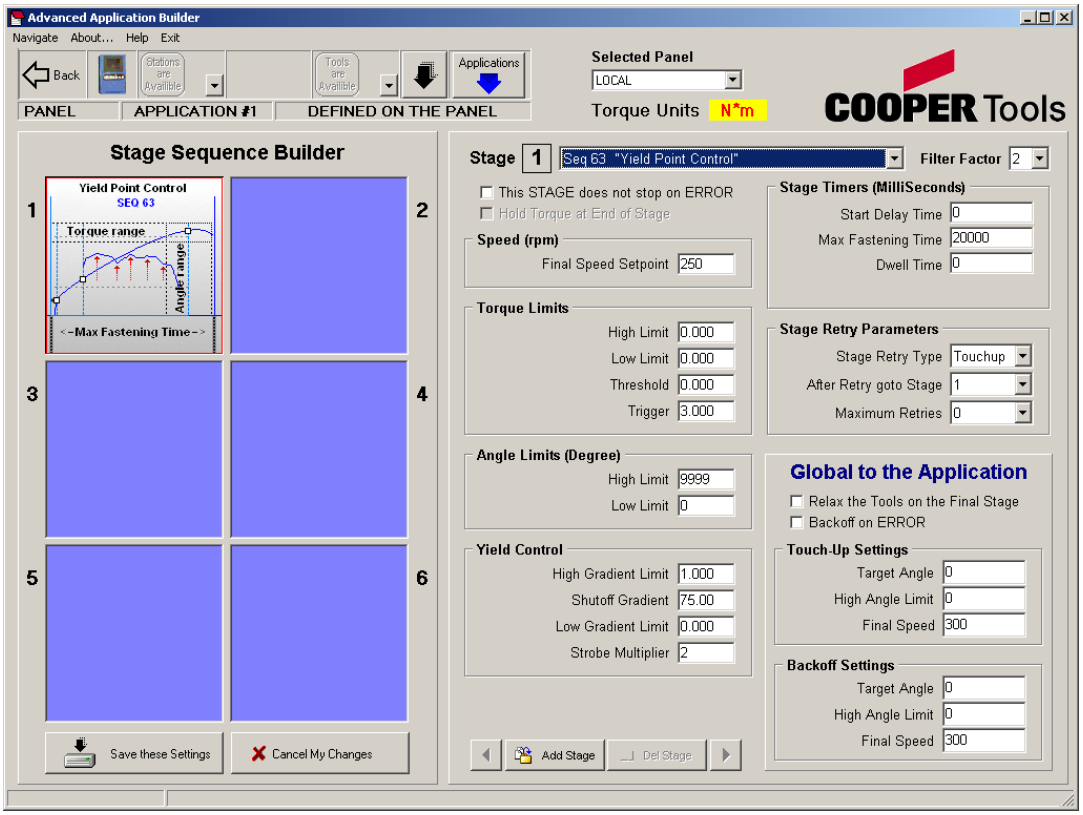
Parameters that are analyzed in reverse, i.e. starting from the shut-off point

Parameter	Start	End	Deactivation
High evaluation angle	Shut-off point minus upper unweighted angle	Shut-off point minus upper unweighted angle minus high evaluation angle	High evaluation angle = 0
Upper unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
High evaluation torque	Valid in the high evaluation angle		High evaluation angle = 0

Parameter	Start	End	Deactivation
Low evaluation angle	Shut-off point minus lower unweighted angle	Shut-off point minus lower unweighted angle minus low evaluation angle	Low evaluation angle = 0
Lower unweighted angle	Shut-off point	Shut-off point minus upper unweighted angle	---
Low evaluation torque	Valid in the low evaluation angle		Low evaluation angle = 0

Yield Point Control
Sequence 63

The purpose of the Yield Point Control Fastening Strategy is to provide the ability to control a fastening to stop after a yielding condition has been detected based on torque/angle. Yield point controlled fastening includes torque, angle and gradient monitoring. In Sequence 63, yield must be attained to declare a good fastening rundown. Yield creates a permanent elongation of the bolt. Typically, the elongation from bolt to bolt should be consistent and in the range of 2 to 4 thousandths of an inch permanent elongation. The bolt elongation is controlled by the calculated ratio of torque over angle. This ratio is called gradient.



Sequence 63 Yield Point Control

At Yield-Threshold, the TM module begins collecting torque/angle data and calculates a running 'slope' (gradient) or 'rate of change'. The maximum 'slope' is remembered and compared against the Gradient setpoint to see if the 'slope' has dropped off enough to indicate that the fastener is yielding. A filtering mechanism is provided to negate false yield detection and is described below. However, once the criteria for yield are met, the TM module will command the fastening to stop and qualify the fastening.
Following Threshold Torque, the yield control algorithm takes samples of the torque angle relationship. These samples are taken at intervals defined by the Strobe Multiplier setpoint (number of angle pulses/sample). The number of angle pulses defines how many samples are necessary per gradient (slope) calculation. Note that every new sample will result in a new slope....the oldest sample is discarded every time a new one is seen. Every new slope is compared to the maximum slope that has been seen in that cycle.
If the slope is steeper, it replaces the present value which then becomes the maximum slope. If less steep, it is checked to see if it falls below the maximum slope by a percentage defined by the setpoint Gradient. As an additional guard against false yield detects, the Strobe Multiplier setpoint defines the number of consecutive degrees that yielding slopes must be seen before an actual yield event is declared. The Shut-off Gradient terminates the sequence. This is a target value and occurs when the Shut-off Gradient percentage of maximum gradient is reached.

The following listing of parameters can be edited on the Sequence 63 Yield Point Control screen:

- Torque High Limit
- Torque Low Limit
- Threshold Torque (start angle)
- Turn Off Torque Stage 1
- Trigger (start O'scope)
- Angle Low Limit
- Angle High Limit
- Stage 1 Speed (initial)
- Stage 2 Speed (final)
- Minimum Gradient
- Maximum Gradient
- Shut-off Gradient
- Strobe Multiplier

Sequence 63
Set Point Definitions

Parameter and Range of Values	Definition
Shut-Off Gradient 0 to 100 %	Percentage of the maximum gradient as target value. When it is reached, the sequence is terminated. If the gradient drops to this percentage of the maximum value, the sequence is terminated.
Minimum Gradient --99.99 to 99.99	Low limit of gradient. If this limit is not reached, the rundown is terminated (safety shutoff) and the stage is evaluated as NOK.
Maximum Gradient --99.99 to 99.99	High limit of gradient. If this limit is exceeded, the rundown is terminated (safety shutoff) and the stage is evaluated as NOK.
Minimum Angle 0 to 9,999	Low limit of angle. If this limit value is not reached, the stage is evaluated NOK.
Maximum Angle 0 to 9,999	High limit of angle. If this limit is exceeded, the rundown is evaluated NOK.
Strobe Multiplier 1 to 30	Step width for gradient calculation in angle pulses. After reaching threshold torque, one measuring point in excess of the strobe multiplier value (1 to 30) must be collected before the gradient is calculated. Data collection is made per angle pulse. With each new angle pulse, the oldest value is deleted, and a new gradient is calculated. A strobe multiplier of 1 corresponds to two measuring points in direst sequence.
Trigger Torque 0 to 1.2 x Torque Cal Factor	When this torque is exceeded, the recording for O-Scope begins. If the trigger torque value is higher than the threshold torque, the recording begins when the threshold torque is exceeded.

Sequence 63
Set Point Definitions cont'd

Parameter and Range of Values	Definition
Minimum Torque 0 to Torque Cal Factor	Low limit of torque. If this limit value is not reached, the stage is evaluated NOK.
Filtering Factor 1, 2, 4, 8, 16, 32	Number of torque values used to calculate a mean value used in all torque related parameters including gradient and shutoff. The oldest value is deleted as soon as a new value is measured. A filtering factor of 1 results in no mean value being calculated.
Spindle Speed 1 to maximum rpm	Programmed speed of the tool socket measured in revolutions per minute.
Maximum Torque 0 to Torque Cal Factor	High limit of torque. If this limit is exceeded, the rundown is evaluated NOK.
Threshold Torque 0 to 1.2 x Torque Cal Factor	When this torque is exceeded, angle counting and gradient calculation begins. After reaching threshold torque, one measuring point in excess of the strobe multiplier value (1 to 30) must be collected before the gradient is calculated. If the threshold torque is set lower than the trigger torque, then O'Scope evaluation begins when threshold torque is exceeded.

General Information Concerning Gradient-Controlled Fastening Strategies (Sequence 63, Sequence 73, Sequence 75, Sequence 78)

Definition:
The gradient is the difference quotient of two measuring points consisting of torque and angle
measured per angle pulse.

$$Gd = \frac{Tqn - Tqm}{ANn - ANm}$$

m, n: index of respective measuring point
n-m = spacing of measuring points = polling rate

Expressed for the practice of fastening technology:

The gradient is the change of torque per degree of angle.

A positive gradient means increase, a negative gradient decrease of the torque with increasing
angle.

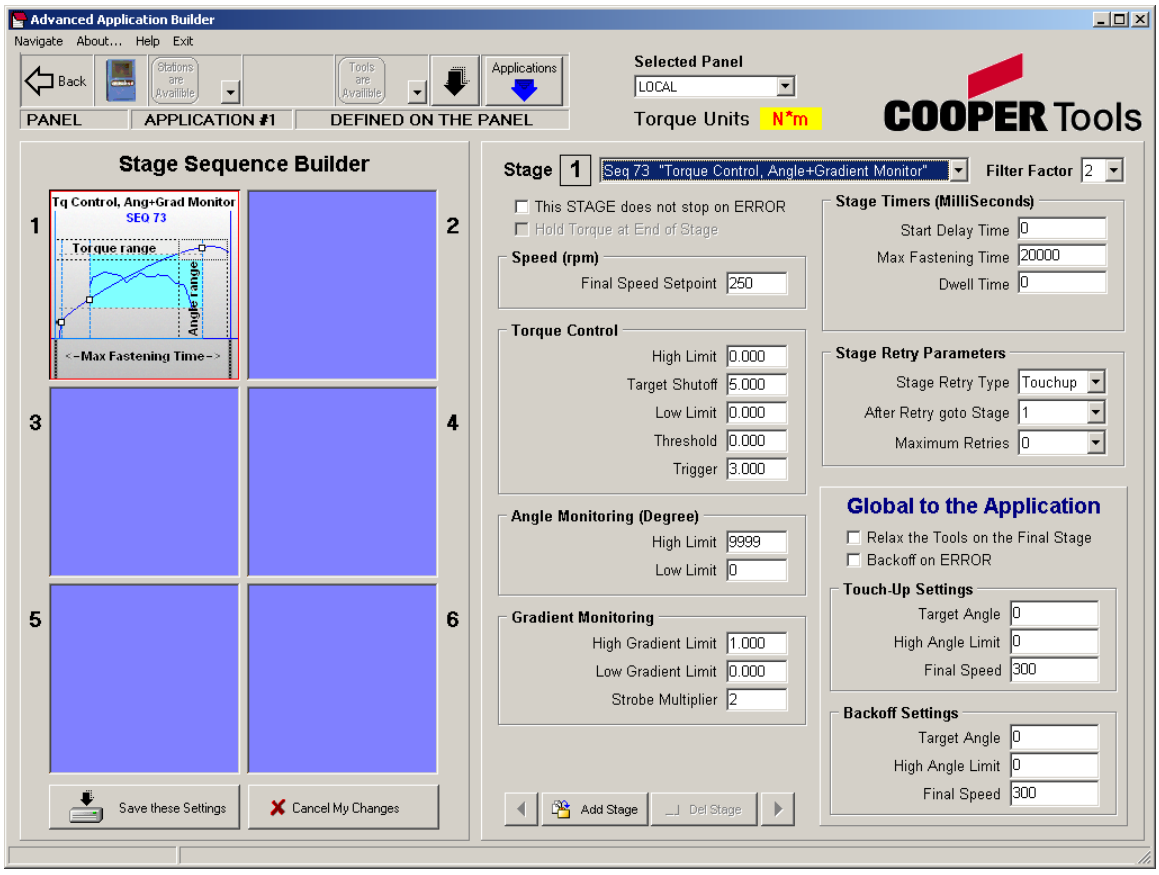
Note, that changing the strobe multiplier will affect the gradient calculation, since a different quotient
is computed thereby. Higher strobe multipliers have a smoothing effect, that is, a change
from a positive to a negative quotient will be detected later.

After the threshold torque has been reached, the gradient is continuously computed of the
torque and angle values.

The gradient calculation ends with the end of the sequence.

Torque Control, Angle and Gradient Monitoring
Sequence 73

Shut-off torque controlled fastening with torque, angle and gradient monitoring



Sequence 73 Torque Control, Angle and Gradient Monitoring

Sequence 73
Setpoint Definitions

Parameter Range of values	Definition
Shut-off torque 0…torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Min. torque 0…Torque cal. Factor	Low limit of torque reached If this limit value is not reached, NOK for the stage results (“Tq<”: Torque too low).
Max. Torque 0…1.2 x Torque cal. Factor	High limit of torque reached If this limit value is exceeded, the stage is evaluated NOK (“Tq>”: Torque too high).
Trigger torque 0…1.2 x Torque cal. Factor	When this torque is exceeded, the recording for graphic representation begins. If the trigger torque value is higher than the threshold torque, the recording already begins when the threshold torque is exceeded.
Threshold torque 0…1.2 x Torque cal factor	When this torque is exceeded, the angle counting and gradient calculation begin. Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. If the threshold torque is lower than the trigger torque, the recording for graphic evaluation begins already when the threshold torque is exceeded.
Min. angle 0…9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).

Sequence 73
Setpoint Definitions cont'd

Parameter Range of values	Definition
Max. angle 0…9,999	High limit of angle reached If this limit is exceeded, the rundown is terminated (safety shut-down) and the stage evaluated NOK ("ANG>": Angle too high).
Min. gradient -99.99…99.99	Low limit of gradient If this limit value is not reached, the stage is evaluated NOK ("Gd<": Gradient too low). The evaluation is made with the value in the min. value memory, not with the gradient prevailing at the time of shut-off.
Max. gradient	High limit of gradient If this limit value is exceeded, the stage is evaluated NOK ("Gd>Gradient too high). The evaluation is made with the value in the max. value memory, not with the gradient prevailing at the time of shut-off.
Strobe multiplier 1…30	Step width for gradient calculation in angle pulses. Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. Collection is made per angle pulse. With each new measuring point (each angle pulse) the oldest measuring value is deleted and a new gradient calculated. A strobe multiplier of 1 corresponds to two measuring points in direct sequence.
Speed 1…max speed	Set speed of the spindle's output shaft
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (gradient calculation, shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

General Information Concerning Gradient-Controlled Fastening Strategies (Sequence 63, Sequence 73, Sequence 75, Sequence 78)

Definition:
The gradient is the difference quotient of two measuring points consisting of torque and angle
measured per angle pulse.

$$Gd = \frac{Tqn - Tqm}{ANn - ANm}$$

m, n: index of respective measuring point
n-m = spacing of measuring points = polling rate

Expressed for the practice of fastening technology:

The gradient is the change of torque per degree of angle.

A positive gradient means increase, a negative gradient decrease of the torque with increasing
angle.

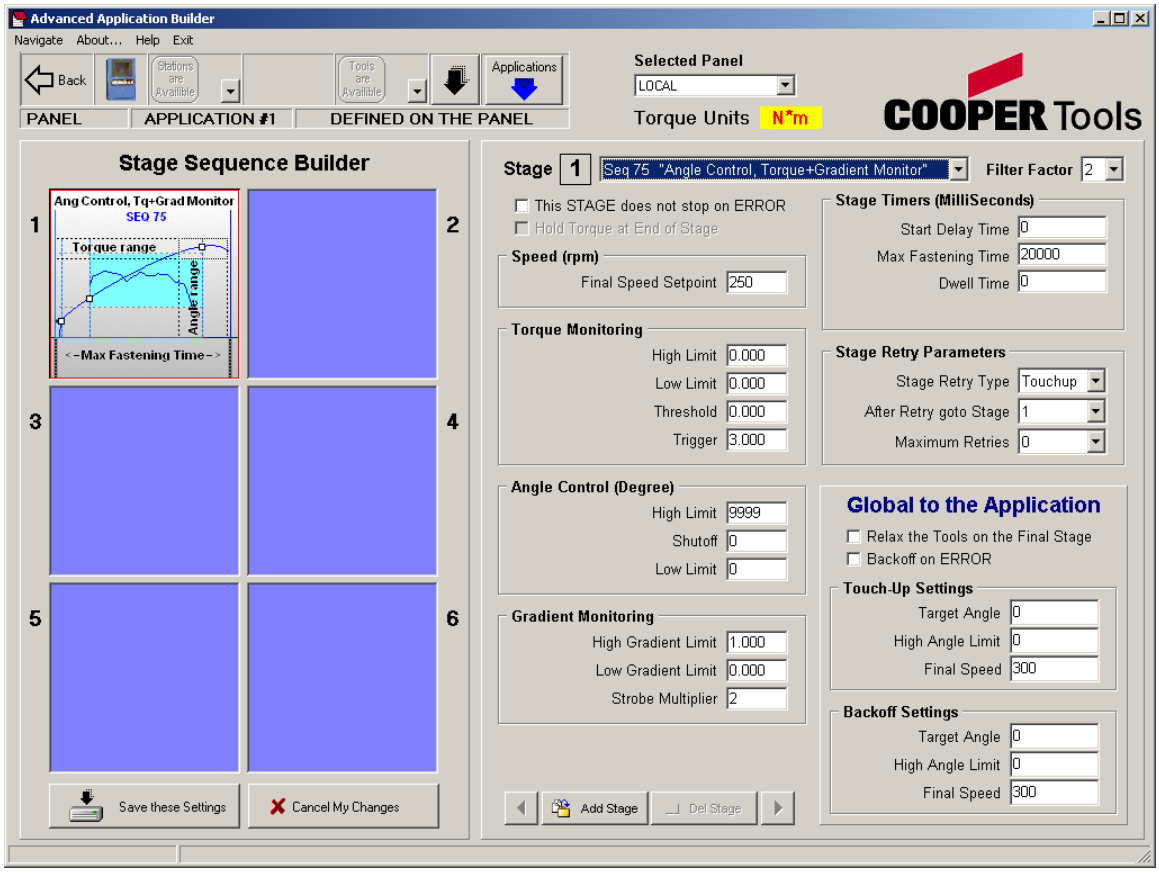
Note, that changing the strobe multiplier will affect the gradient calculation, since a different quotient
is computed thereby. Higher strobe multipliers have a smoothing effect, that is, a change
from a positive to a negative quotient will be detected later.

After the threshold torque has been reached, the gradient is continuously computed of the
torque and angle values.

The gradient calculation ends with the end of the sequence.

Angle Control, Torque and Gradient Monitor
Sequence 75

Shut-off angle controlled fastening with torque, angle and gradient monitoring



Sequence 75 Angle Control, Torque and Gradient Monitor

Sequence 75
Setpoint Definitions

Parameter Range of values	Definition
Shut-off angle 0…9,999	Angle as target value; when it is reached, the rundown is terminated
Min. angle 0…9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”:Angle too low)
Max. angle 0…9,999	High limit of angle reached If this limit value is exceeded, the stage is evaluated NOK (“ANG>”angle too high).
Trigger torque 0…1.2 x torque cal. Factor	When this torque is exceeded, the recording for graphic representation begins. If the trigger torque value is higher than the threshold torque, the recording already begins when the threshold torque is exceeded.
Threshold torque 0…1.2 x Torque cal. Factor	When this torque is exceeded, the angle counting and gradient calculation begin. Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. If the threshold torque is lower than the trigger torque, the recording for graphic evaluation begins already when the threshold torque is exceeded.
Min. torque 0…Torque cal. Factor	Low limit of torque reached. If this limit value is not reached, NOK for the stage results (“Tq<”: Torque too low).

Sequence 75
Setpoint Definitions cont'd

Parameter Range of Values	Definition
Max. torque 0…1.2 x Torque cal. Factor	High limit of torque reached If this limit is exceeded, the rundown is terminated (safety shut-down), the stage is evaluated NOK ("Tq>": Torque too high).
Min. gradient -99.99…99.99	Low limit of gradient If this limit is not reached, the stage is evaluated NOK ("Gd<":Gradient too low). The evaluation is made with the value in the min. value memory, not with the gradient prevailing at the time of shut-off.
Max. gradient -99.99…99.99	High limit of gradient If this limit value is exceeded, the stage is evaluated NOK ("Gd>": Gradient too high). The evaluation is made with the value in the max. value memory, not with the gradient prevailing at the time of shut-off.
Strobe multiplier 1…30	Step width for gradient calculation in angle pulses Starting from reaching the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. Collection is made per angle pulse. With each new measuring point (each angle pulse) the oldest measuring value is deleted and a new gradient calculated. A strobe multiplier of 1 corresponds to two measuring points in direct sequence.
Speed 1…max. speed	Set speed of the spindle's output shaft
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (gradient calculation, shut-off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

General Information Concerning Gradient-Controlled Fastening Strategies (Sequence 63, Sequence 73, Sequence 75, Sequence 78)

Definition:
The gradient is the difference quotient of two measuring points consisting of torque and angle
measured per angle pulse.

$$Gd = \frac{Tqn - Tqm}{ANn - ANm}$$

m, n: index of respective measuring point
n-m = spacing of measuring points = polling rate

Expressed for the practice of fastening technology:

The gradient is the change of torque per degree of angle.

A positive gradient means increase, a negative gradient decrease of the torque with increasing
angle.

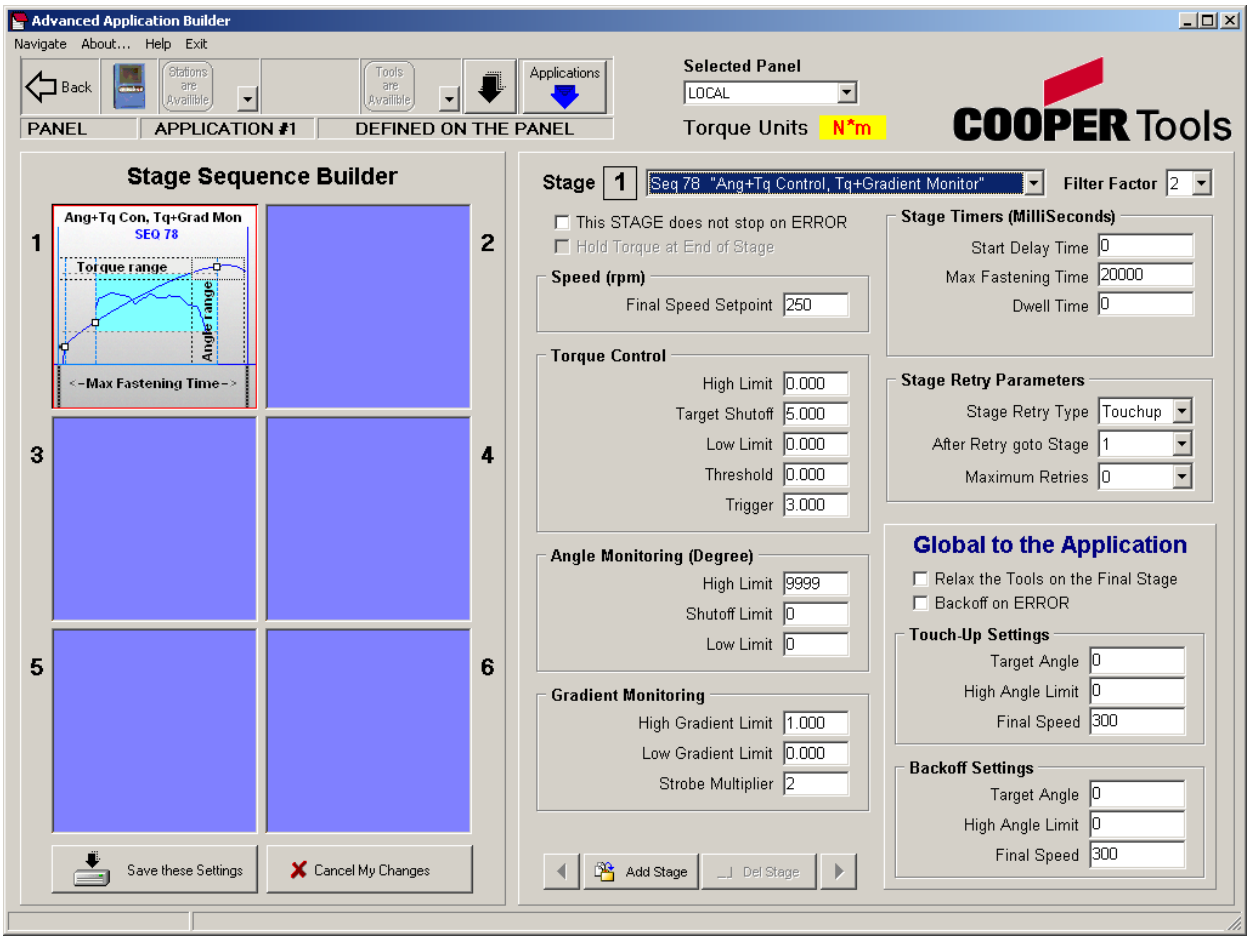
Note, that changing the strobe multiplier will affect the gradient calculation, since a different quotient
is computed thereby. Higher strobe multipliers have a smoothing effect, that is, a change
from a positive to a negative quotient will be detected later.

After the threshold torque has been reached, the gradient is continuously computed of the
torque and angle values.

The gradient calculation ends with the end of the sequence.

Torque Control, Angle and Gradient Monitor
Sequence 78

Shut-off torque and shut-off angle controlled fastening with torque, angle and gradient monitoring



Sequence 78 Torque Control, Angle and Gradient Monitor

Sequence 78 is a combination of Sequence 73 and Sequence 75. A shut-off torque and a shut-off angle can be programmed as target values. If at least one of the two target values is reached, the rundown is terminated.

Sequence 78
Set Point Definitions

Parameter Range of Values	Definition
Shut-off torque 0…Torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Max. torque 0…1.2 x Torque cal. Factor	High limit of torque reached If this limit value is exceeded, the stage is evaluated NOK (“Tq>”:Torque too high).
Min. angle 0…9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Trigger torque 0…1.2 x Torque cal Factor	When this torque is exceeded, the recording for graphic representation beings. If the trigger torque value is higher than the threshold torque, the recording already begins when the threshold torque is exceeded.
Strobe multiplier 1…30	Step width for gradient calculation in angle pulses Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. Collection is made per angle pulse. With each new measuring point (each angle pulse) the oldest measuring value is deleted and a new gradient calculated. A strobe multiplier of 1 corresponds to two measuring points in direct sequence.
Max. gradient -99.99…99.99**	High limit of gradient If this limit value is exceeded, the stage is evaluated NOK (“Gd>”: Gradient too high). The evaluation is made with the value in the max. value memory , not with the gradient prevailing at the time of shut-off.
Min. gradient -99.99…99.99**	Low limit of gradient If this limit value is not reached, the stage is evaluated NOK (“Gd<”: Gradient too low). The evaluation is made with the value in the min. value memory, not with the gradient prevailing at the time of shut-off.

** This input range applies to Nm for torque. Recalculated input ranges apply other torque measuring units.

Sequence 78
Set Point Definitions (cont'd)

Parameter Range of Values	Definition
Min torque 0…Torque cal. Factor	Low limit of torque reached If this limit value is not reached, NOK for the stage results (Tq<": Torque too low)
Shut-off angle 0…9,999	Angle as target value; when it is reached, the rundown is terminated.
Max. angle 0…9,999	High limit of angle reached If this limit value is exceeded, the stage is evaluated NOK ("ANG>": Angle too high).
Speed 1…max speed	Set speed of the spindle's output shaft
Threshold torque 0…1.2 x Torque cal factor	When this torque is exceeded, the angle counting and gradient calculation begin. Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. If the threshold torque is lower than the trigger torque, the recording for graphic evaluation begins already when the threshold torque is exceeded.
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (gradient calculation, shut off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

General Information Concerning Gradient-Controlled Fastening Strategies (Sequence 63, Sequence 73, Sequence 75, Sequence 78)

Definition:
The gradient is the difference quotient of two measuring points consisting of torque and angle
measured per angle pulse.

$$Gd = \frac{Tqn - Tqm}{ANn - ANm}$$

m, n: index of respective measuring point
n-m = spacing of measuring points = polling rate

Expressed for the practice of fastening technology:

The gradient is the change of torque per degree of angle.

A positive gradient means increase, a negative gradient decrease of the torque with increasing
angle.

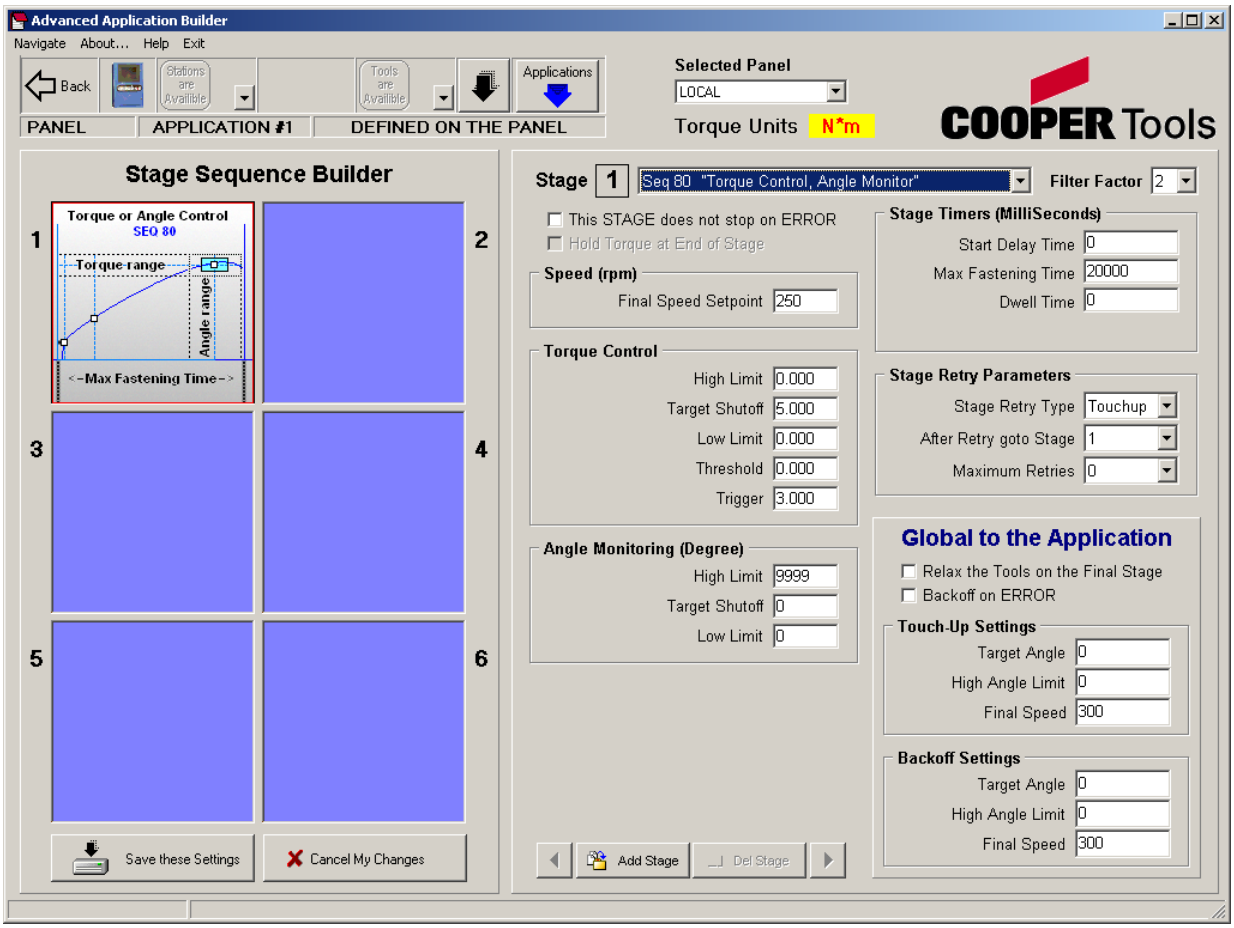
Note, that changing the strobe multiplier will affect the gradient calculation, since a different quotient
is computed thereby. Higher strobe multipliers have a smoothing effect, that is, a change
from a positive to a negative quotient will be detected later.

After the threshold torque has been reached, the gradient is continuously computed of the
torque and angle values.

The gradient calculation ends with the end of the sequence.

Torque and Angle Control, with Torque and Angle Monitoring Sequence 80

Shut-off torque and shut-off angle (whichever occurs first) with torque and angle monitoring.



Sequence 80 Torque and Angle Control, with Torque and Angle Monitoring

Sequence 80 is a combination of Sequence 73 and Sequence 75. A shut-off torque and a shut-off angle can be programmed as target values. If at least one of the two target values is reached, the rundown is terminated. Torque and Angle are both monitored.

Sequence 80
Set Point Definitions

Parameter Range of Values	Definition
Shut-off torque 0…Torque cal. Factor	Torque as target value; when it is reached, the sequence is terminated.
Max. torque 0…1.2 x Torque cal. Factor	High limit of torque reached If this limit value is exceeded, the stage is evaluated NOK (“Tq>”:Torque too high).
Min. angle 0…9,999	Low limit of angle reached If this limit value is not reached, an NOK for the stage results (“ANG<”: Angle too low).
Trigger torque 0…1.2 x Torque cal Factor	When this torque is exceeded, the recording for graphic representation beings. If the trigger torque value is higher than the threshold torque, the recording already begins when the threshold torque is exceeded.
Strobe multiplier 1…30	Step width for gradient calculation in angle pulses Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. Collection is made per angle pulse. With each new measuring point (each angle pulse) the oldest measuring value is deleted and a new gradient calculated. A strobe multiplier of 1 corresponds to two measuring points in direct sequence.
Max. gradient -99.99…99.99**	High limit of gradient If this limit value is exceeded, the stage is evaluated NOK (“Gd>”: Gradient too high). The evaluation is made with the value in the max. value memory , not with the gradient prevailing at the time of shut-off.
Min. gradient -99.99…99.99**	Low limit of gradient If this limit value is not reached, the stage is evaluated NOK (“Gd<”: Gradient too low). The evaluation is made with the value in the min. value memory, not with the gradient prevailing at the time of shut-off.

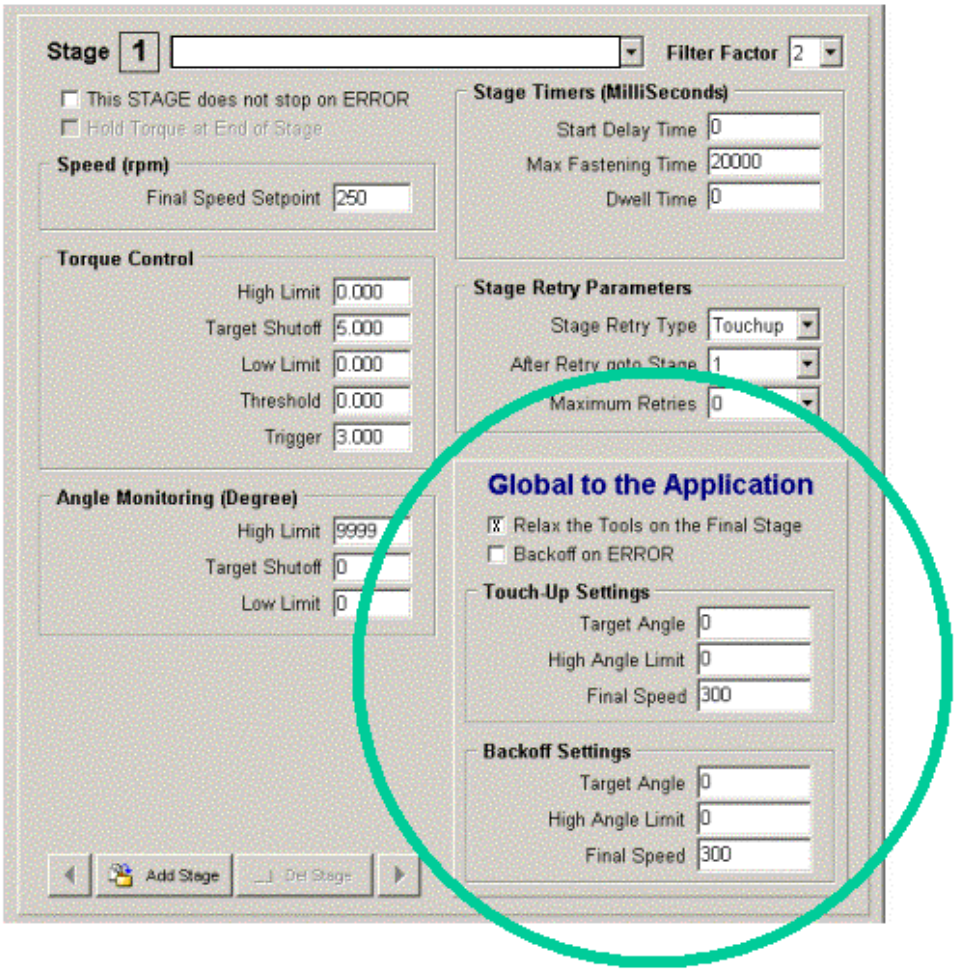
** This input range applies to Nm for torque. Recalculated input ranges apply other torque measuring units.

Sequence 80
Set Point Definitions cont'd

Min torque 0…Torque cal. Factor	Low limit of torque reached If this limit value is not reached, NOK for the stage results (Tq<": Torque too low)
Shut-off angle 0…9,999	Angle as target value; when it is reached, the rundown is terminated.
Max. angle 0…9,999	High limit of angle reached If this limit value is exceeded, the stage is evaluated NOK ("ANG>": Angle too high).
Speed 1…max speed	Set speed of the spindle's output shaft
Threshold torque 0…1.2 x Torque cal factor	When this torque is exceeded, the angle counting and gradient calculation begin. Starting from reaching of the threshold torque, one measuring point in excess of the strobe multiplier must have been collected, for the first gradient value to be computed. If the threshold torque is lower than the trigger torque, the recording for graphic evaluation begins already when the threshold torque is exceeded.
Filtering factor 1, 2, 4, 8, 16, 32	Number of torque values used to find mean value With this number of torque values a mean value is calculated immediately upon measurement, corresponding to filtering and dampening. As soon as a new value is measured, the oldest value is deleted and the mean value recalculated. The further evaluation (gradient calculation, shut off, evaluation, graph) is made with these mean values. A filtering factor of 1 results in no mean values being computed.

Relax
Sequence Parameter 193

Relaxes pressure on the spindle sockets for easy withdraw of the spindles from the part.



Sequence Parameter 193 Relax

Sequence Parameter 193 is applied to the last stage in the fastening rundown. It is designed to relax pressure on the spindle sockets by reversing 1 to 3 degrees at the conclusion of a rundown. This permits easy withdraw of the multiple spindles from the part. Select “Relax the Tools on the Final Stage” by placing an “X” in the selection block.

SECTION 12

Input – Output Overview

The Tork-Trak TM Controller supports a variety of Input – Output Functions:

- Discrete Physical I-O
- Discrete Virtual I-O (Refer to the Fieldbus Section 14)
- Active High and Active Low Discrete Physical I-O
- Mappable User Programmable I-O

This Section on Input – Output functionality provides an Overview of the TM Controller capability concerning Discrete Physical I-O, and I-O programming.

There are two classes of Physical Discrete I-O supported by the Tork-Trak TM (T3M) controller. The first class is the PRIVATE I-O which is intended primarily as I-O internal to the TM3 controller.
The private I-O is not mappable, and is hard-wired to support:

- Qty 8 Indicator Light Outputs
- Trigger Start Input
- Tool Reverse Input
- Tool In-Cycle Output
- Cycle Complete Output

PRIVATE I-O is shipped as a STANDARD feature of the Tork-Trak TM Controller.

The second class is PUBLIC I-O which is intended primarily as I-O external to the TM3 controller. The Public I-O is software mappable by the User.

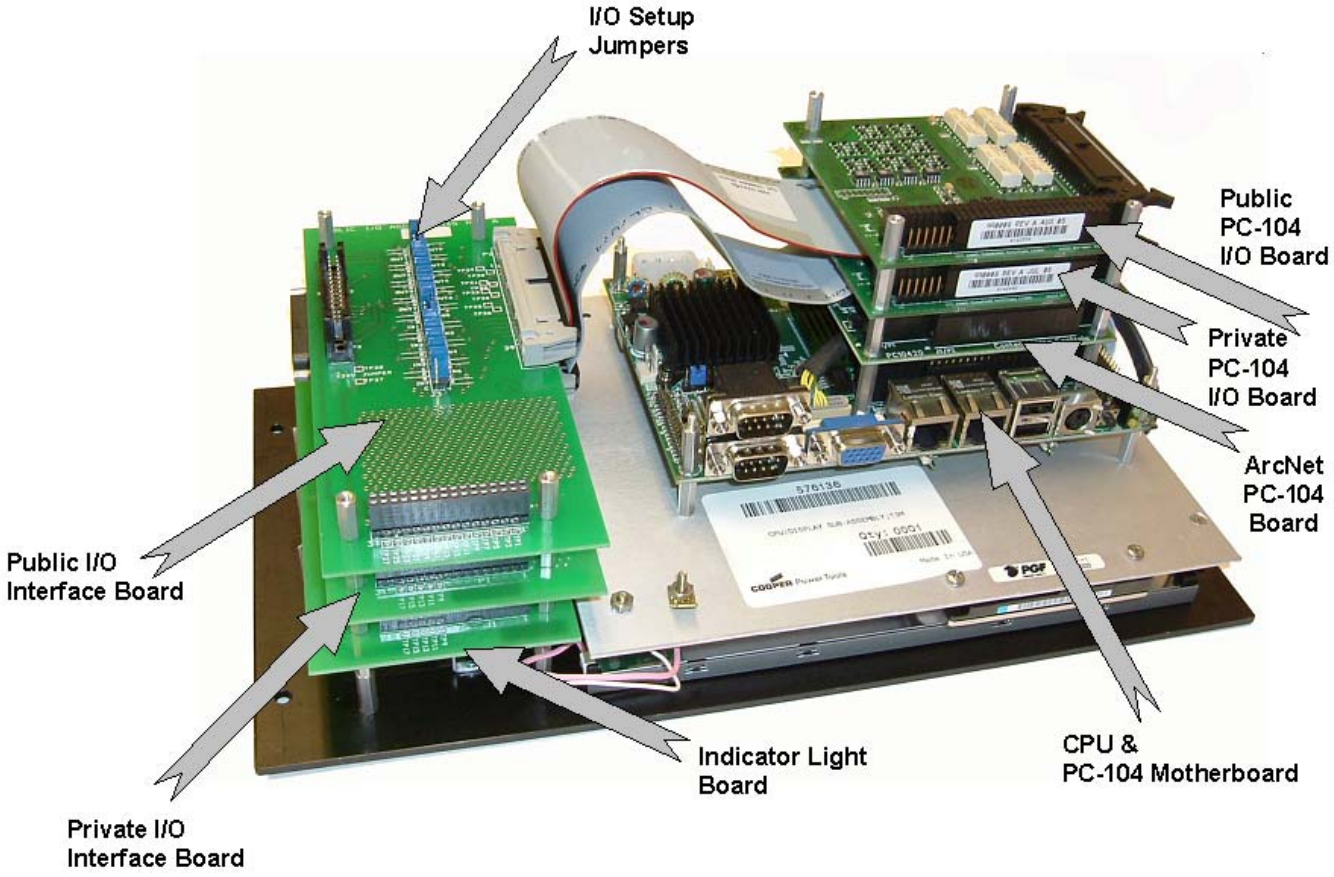
PUBLIC I-O is shipped as an OPTIONAL feature of the Tork-Trak TM Controller.

Each class of I-O is available to the User through two 25 pin connectors on the Connector Plate located below the enclosure door. The Public I-O connector (male pins) is mounted toward the front of the enclosure and the Private I-O connector (female pins) is mounted toward the rear of the controller.

The Tork-Trak TM supports I/O operation from an external 24 VDC supply (PLC), or from the 24 VDC power supply internal to the Tork-Trak TM Controller.

The Tork-Trak TM also supports I/O operation as Active High or Active Low (Source or Sink), permitting a mix of Active High or Active Low Inputs and Outputs. This I/O setup is accomplished by positioning jumpers on the I/O Interface Board located on the CPU and Indicator Light Sub-Assembly. Refer to the following illustration. Details of the I/O jumper positions will be discussed later in this Section 12.

CPU and Display Sub Assembly



PRIVATE OUTPUT Pinout: Discrete Physical I-O

PRIVATE I/O Connector Pin Assignment	OUTPUT Description	Pre-Assigned FUNCTION
1	+ 24 VDC	
2	+ 24 VDC	
3	OUTPUT 9	Torque High Indicator Light
5	OUTPUT 10	Angle High Indicator Light
7	OUTPUT 11	Cycle Accept Indicator Light
9	OUTPUT 12	Cycle Reject Indicator Light
11	OUTPUT 13	Torque Low Indicator Light
13	OUTPUT 14	Angle Low Indicator Light
15	OUTPUT 15	In-Cycle
17	OUTPUT 16	Cycle Complete
19	Spare	
20	Spare	
21	Spare	
22	Spare	
23	DC COMMON 24 V return from Internal Power Supply	
24	DC COMMON 24 V return from Internal Power Supply	
25	no connection	

NOTES:

1. All PRIVATE Outputs are on the rear 25 pin female connector
2. Mating male connector: Cooper Power Tools 576211
   Phoenix Contact Subcon 25/F-SH 27-61-62-2
3. Functions are pre-assigned and not changeable
4. PRIVATE I/O is Internal 24 VDC only, connection to external 24 V is not recommended
5. PRIVATE I/O is Active High, only.

PRIVATE INPUT Pinout: Discrete Physical I-O

PRIVATE I/O Connector Pin Assignment	INPUT Description	Pre-Assigned FUNCTION
1	+ 24 VDC	
2	+ 24 VDC	
4	INPUT 9	Trigger Start
6	INPUT 10	Reverse
8	INPUT 11	
10	INPUT 12	
12	INPUT 13	
14	INPUT 14	
16	INPUT 15	
18	INPUT 16	
19	Spare	
20	Spare	
21	Spare	
22	Spare	
23	DC COMMON 24 V return from Internal Power Supply	
24	DC COMMON 24 V return from Internal Power Supply	
25	no connection	

NOTES:

1. All PRIVATE Inputs are on the rear 25 pin female connector
2. Mating male connector: Cooper Power Tools 576211
   Phoenix Contact Subcon 25/F-SH 27-61-62-2
3. Functions are pre-assigned and not changeable
4. PRIVATE I/O is Internal 24 VDC only, connection to external 24 V is not recommended
5. PRIVATE I/O is Active High, only.

PUBLIC OUTPUT Pinout: Discrete Physical I-O

PUBLIC I/O Connector Pin Assignment	OUTPUT Description	Pre-Assigned FUNCTION
3	OUTPUT 1	User Mappable
4	OUTPUT 2	User Mappable
5	OUTPUT 3	User Mappable
6	OUTPUT 4	User Mappable
7	OUTPUT 5	User Mappable
8	OUTPUT 6	User Mappable
9	OUTPUT 7	User Mappable
10	OUTPUT 8	User Mappable
14	+ 24 VDC thru external fuse on enclosure	
11	24 V return (DC common)	
2	Output Bus common A	
1	Output Bus common B	
12	Output Bus common C	
13	no connection	

NOTES:

1. All PUBLIC Outputs are on the forward 25 pin male connector
2. Mating female connector: Cooper Power Tools 576191
   Phoenix Contact Subcon 25/F-SH 27-61-61-9
3. Functions are software mappable by the User.
4. PUBLIC I/O can be either Internal 24 VDC, or External 24 VDC.
5. PUBLIC I/O can be either Active High, or Active Low.

PUBLIC INPUT Pinout: Discrete Physical I-O

PUBLIC I/O Connector Pin Assignment	OUTPUT Description	Pre-Assigned FUNCTION
15	INPUT 1	User Mappable
16	INPUT 2	User Mappable
17	INPUT 3	User Mappable
18	INPUT 4	User Mappable
19	INPUT 5	User Mappable
20	INPUT 6	User Mappable
21	INPUT 7	User Mappable
22	INPUT 8	User Mappable
14	+ 24 VDC thru external fuse on enclosure	
11	24 V return (DC common)	
23	Input Bus common A	
24	Input Bus common B	
25	Input Bus common C	
13	no connection	

NOTES:

1. All PUBLIC Inputs are on the forward 25 pin male connector
2. Mating female connector: Cooper Power Tools 576191
   Phoenix Contact Subcon 25/F-SH 27-61-61-9
3. Functions are software mappable by the User.
4. PUBLIC I/O can be either Internal 24 VDC, or External 24 VDC.
5. PUBLIC I/O can be either Active High, or Active Low.

DISCRETE PHYSICAL I-O Setup

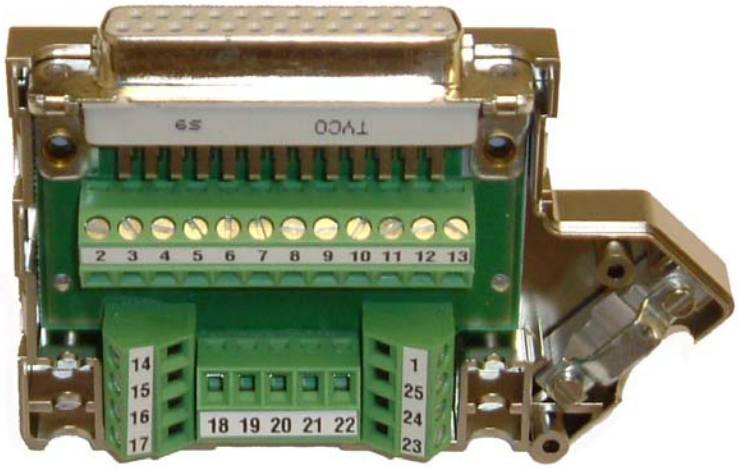
As previously discussed earlier in this Section, the Tork-Trak TM Controller supports several different discrete Input and Output configurations. In addition to User mappable I/O functions, this also includes:

- External 24 VDC
- Internal 24 VDC
- Active High Input
- Active Low Input
- Active High Output
- Active Low Output

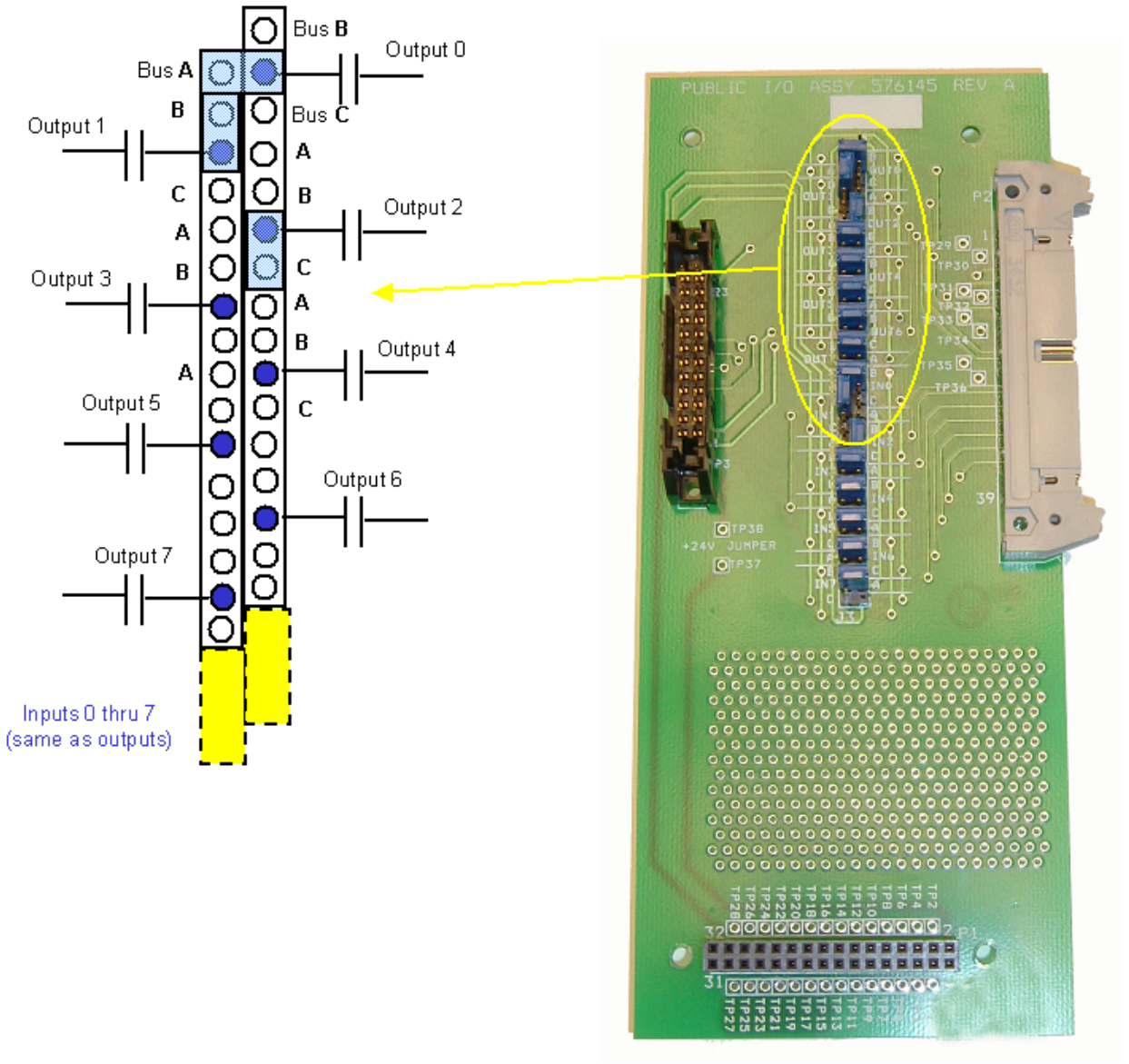
Mapping I/O functions is accomplished by User programming of the controller Software.

Changes from Active High / Active Low and External / Internal 24 VDC are accomplished by moving jumpers located on the Public I/O Interface Board and adding wire jumpers inside the external I/O 25 pin cable connector. The mating 25 pin I/O connector is designed with miniature screw terminals, making jumper changes very fast and easy.

External 25 Pin Mating I/O Cable Connector with Screw Terminal Connections (PUBLIC Female Cable Connector Shown)



Public I-O Interface Board Showing Input and Output Common Bus Jumpers



In order to set jumpers, the CPU and Display Sub Assembly must be removed from the enclosure. The jumpers are located on the top board. There are 16 jumpers. Starting from the top of the board, the jumpers are labeled Output 0 thru Output 7 and Input 0 thru Input 7.

Tork-Trak Default Public I-O Configuration

As shipped from the factory, the standard default settings for Physical Discrete I/O is:

- All OUTPUT jumpers on the I/O Interface Board are connected to the Output Bus Common A
- All INPUT jumpers on the I/O Interface Board are connected to the Input Bus Common A
- No wiring jumpers are installed for Internal or External 24 VDC
- No wiring jumpers are installed for Active High or Active Low

Wire Jumpers for Public I-O Setup within the I/O Cable Connector

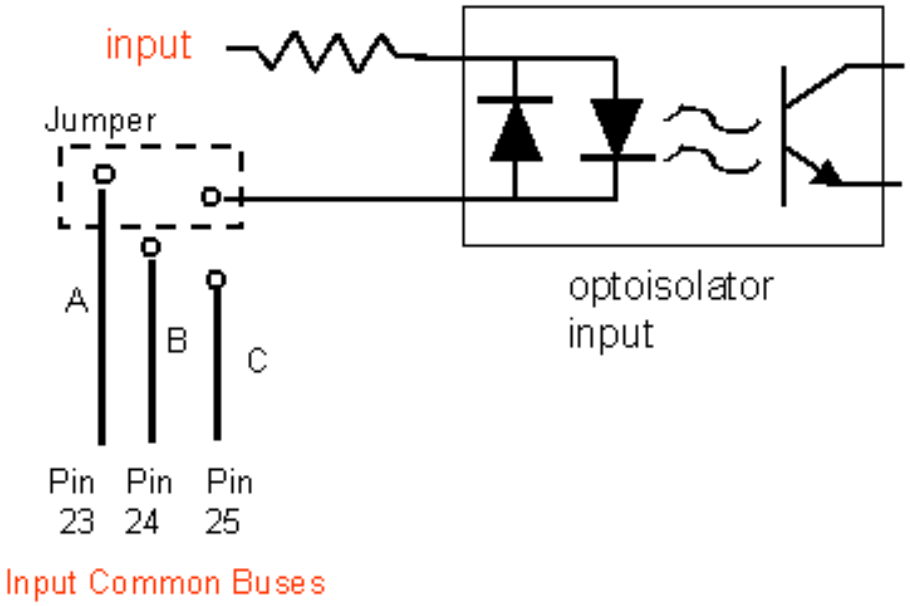
Public Inputs and Outputs have 3 common buses designated A, B and C. There are a total of 6 Common Buses:

- Output Bus Common A
- Output Bus Common B
- Output Bus Common C
- Input Bus Common A
- Input Bus Common B
- Input Bus Common C

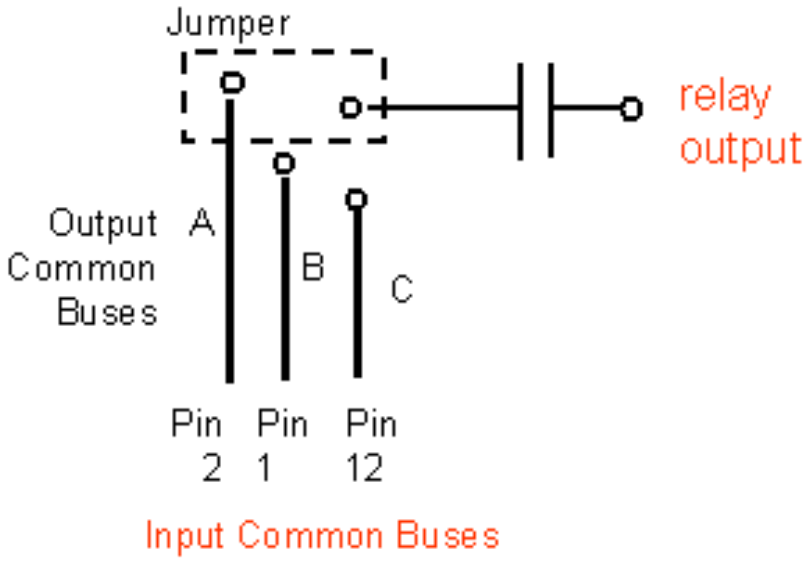
Each individual common bus can be connected to 1 of 5 functions:

- Internal 24 VDC
- External 24 VDC
- Active High + 24 VDC
- Active Low − 24 VDC return
- 1 to 8 INPUTS or 1 to 8 OUTPUTS

Schematic of the typical photo isolated, bi-directional INPUT



Schematic of the typical Relay OUTPUT



I/O Setup Instructions

Internal 24 VDC, All Inputs and Outputs Active High

1. On the Public I/O cable connector, jumper pins 14 (+24 VDC) to 2 (Output, Common A)
2. On the Public I/O cable connector, jumper pins 11 (DC common) to 23 (input Common A)
3. On the I/O interface Board, set all jumpers to Input Common A and Output Common A

External 24 VDC, All Inputs and Outputs Active High

1. On the Public I/O cable connector, connect the external + 24 VDC to pin 2 (Output Common A)
2. On the Public I/O cable connector, connect the external 24 VDC common to pin 23 (Input Common A)
3. On the I/O interface Board, set all jumpers to Input Common A and Output Common A

Internal 24 VDC, All Inputs and Outputs Active Low

1. On the Public I/O cable connector, jumper pins 11 (DC Common) to 2 (Output, Common A)
2. On the Public I/O cable connector, jumper pins 14 (+ 24 VDC) to 23 (Input Common A)
3. On the I/O interface Board, set all jumpers to Input Common A and Output Common A

External 24 VDC, All Inputs and Outputs Active Low

1. On the Public I/O cable connector, connect the external 24 VDC com to pin 2 (Output, Common A)
2. On the Public I/O cable connector, connect the external + 24 VDC to pin 23 (Input Common A)
3. On the I/O interface Board, set all jumpers to Input Common A and Output Common

In order to setup some outputs active high and some outputs active low, make use of all the Output Common Buses A, B or C and Input Common Buses A, B or C.

As an example, if an **output** needs to be Active Low, connect 24 VDV common to either **output** Common Buss A, B or C and assign the **output** to the appropriate bus using the jumpers on the I/O Interface Board.

If an **input** needs to be Active Low, connect + 24 VDV common to either **input** Common Buss A, B or C and assign the **input** to the appropriate bus using the jumpers on the I/O Interface Board.

Internal 24 VDC, All Inputs Active Low and All Outputs Active High

1. On the Public I/O cable connector, jumper pins 14 to 23 (Inputs Active Low)
2. On the Public I/O cable connector, jumper pins 14 to 1 (Outputs Active High)
3. On the I/O interface Board, set all Output jumpers to Common A and all Input jumpers to Common B

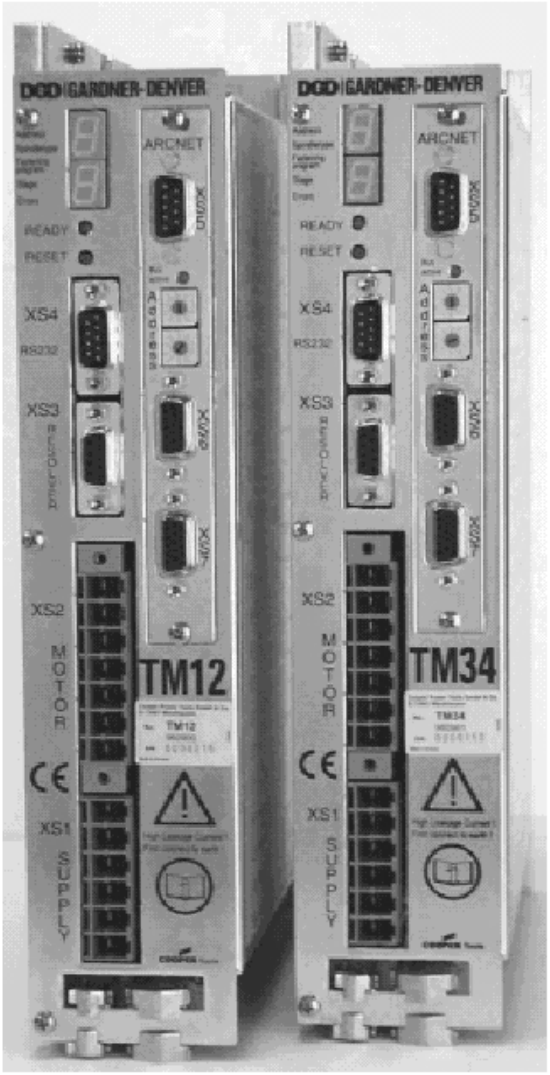
Internal 24 VDC, All Inputs Active High and All Outputs Active Low

1. On the Public I/O cable connector, jumper pin 11 to pin 23 (Inputs Active High)
2. On the Public I/O cable connector, jumper pin 11 to pin 1 (Outputs Active Low)
3. On the I/O interface Board, set all Output jumpers to Common B and all Input jumpers to Common A

SECTION 15

TM Servo Modules for Fixtured Tools

TM12 960900
TM34 960901



General Description of Tightening Modules TM

• In the tightening modules "TM12" and "TM34" the servo amplifier (output section) and
the measuring section (measuring board torque) are integrated in one housing.
• There are separate processors for measuring and output sections.
• Motors are controlled digitally.
• The control parameters for different motors are saved permanently in the TM and are selected by the measuring board.

Field of Application

• The tightening modules have been designed to operate Cooper Tools fastening spindles size
- 1B.. and 2B.. (TM12)
- 3B.. and 4B.. (TM34)
- EMT Series 80 and 200 (TM12)
- EMT Series 400, 600, 800 and 1200 (TM34)
• The tightening modules are used in conjunction with the station controller TM Multi-Trak and Tork-Trak TM Controllers
• The TM communicates with the station controller Tork-Trak TM via a serial high-speed field bus ARCNET.
Thus, decentralized arrangement of station controller and TMs at a distance of up to 100 m is possible.

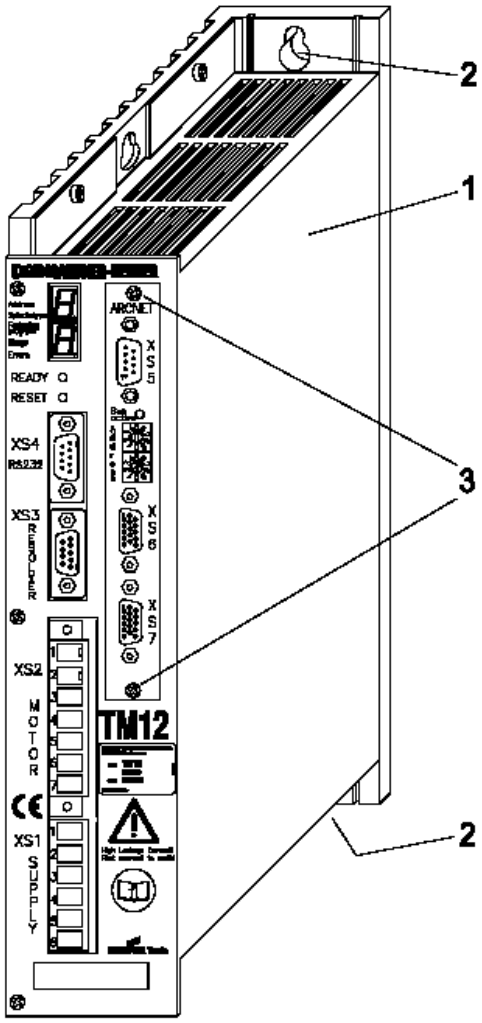
Service

• TMs can be replaced without requiring calibration.
The station controller m-Pro-400 Touch-screen transmits all settings and adjustments
automatically to the new TM.
• Fast, precise diagnosis in case of failures is facilitated by displayed text at the station
controller and coded messages displayed on a 2-digit 7-segment display at the TM.
• If the housing is opened, the warranty is voided.
• The TM must always be replaced in its entirety.
• Only transport the device in the original packing.
• The packing is recyclable.
• If the packing is damaged, check the TM for visible signs of damage. Inform the carrier
and Cooper Tools if required.

Description

- Rugged metal casing. (1)
- Same housing size for all TM types.
- Fastening with M6x20 cap screws to the mounting plate of the control cabinet, through key holes in the TM. (2)

The measuring board can be plugged in and out and is held with two screws in the faceplate. (3)



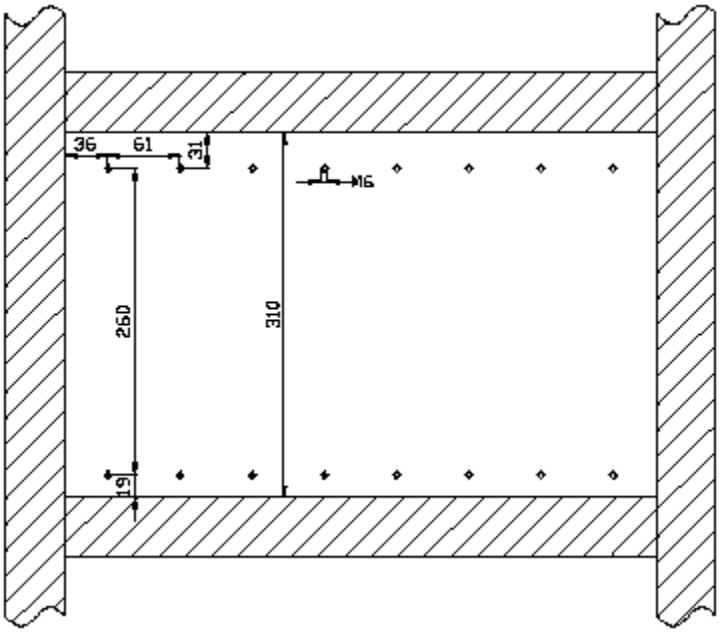
Data

	TM12	TM34
Height	280 mm	
Width	60 mm	
Depth	200 mm	
Maximum depth with plugs	280 mm	
Spacing of mounting holes	260 mm to center	
Weight	3400 g	3420 g
Enclosure type	IP20	
Type of cooling	Convection (self-cooling)	
Ambient temperature	0…50 °C	
Storage temperature	-20…60 °C	
Humidity	0…90 %	
Service life in operating	20,000 h	
Usability for storage	100,000 h (approx. 11 years)	

Installation Guidelines

- A closed steel plate control cabinet must be used.
- A zinc plated mounting plate must be used; it must not be painted.

Drilling sketch



Electromechanical Properties

- All connections are located at the front.
- Two transducers can be connected (redundant setup of measuring sensors according to VDI 2862).
- Fast error diagnosis with 2-digit 7-segment display.
- Current fastening stage and parameter set are displayed by 2-digit 7-segment display.
- LED "READY" indicates ready to operate condition.
- "RESET" button
- Cooper Tools service interface RS232
- ARCNET Addressing with 2 BCD switches.
- LED for ARCNET bus activity.
- The cable shields for motor and resolver cable at the housing are connected with shield connecting components (Cooper Tools Ident No. S960434 and S960435).
- All connectors and housing openings are contact protected (IP20).

Cooper Tools Electric Data

The intermediate circuits of the power section and the logic section are supplied separately. This allows separate power-down of the intermediate circuit of the power section upon EMERGENCY STOP.

The logic power supply unit and therefore all communication assemblies continue to be supplied.

CAUTION!

The internal fuses protect the conductor tracks inside the TM. If defects occur only replace with originally supplied fuses. Do not change voltage or current ratings, or fuse speed

Intermediate Circuit of the Power Section

• Integrated starting current limit by two processor-controlled relays.
The main relay is switched on after the initialization.
The intermediate circuit capacitors are charged through a starting current limiting resistor,
until a voltage of approx. 300 VDC is reached. Thereafter the resistor is bridged by the start-up
relay.
• The TM34 must be operated on a three-phase supply via an isolation transformer approved
by Cooper Tools.

Connector XS1

	TM12		**TM34**	
Nutrunner type	1B..	2B..	3B..	4B..
Supply voltage	1 X 230 VAC ± 10 %		3 X 230 VAC ± 10 %	
Frequency	50-60 Hz			
Rated supply current RMS	1A	2A	3 X 2.5 A	3 X 2.5 A
Peak supply current RMS	8A	16A	3 X 10 A	3 X 16 A
Internal fusing (slow blow)	10A		3 X 10 A	
Starting current limit	5A			

Intermediate Circuit of Logic Section

• All logic voltages and supply voltages for the communication functions are generated from the intermediate circuit of the logic section.

Connector XS1

	TM12	**TM34**
Supply current	1 X 230 VAC ± 10 %	
Frequency	50-60 Hz	
Rated Supply current	approx. 0.1 A	
Internal fusing Error! Bookmark not defined. **(slow blow)**	0.63 A	
Power loss (standby)	24 W	

Internal Power Supply Units

- Supplied by the intermediate circuit of the logic section, galvanically separated.
- All generated voltages are short-circuit protected.
- The ARCNET output level is galvanically separated from all other supplies.
- The clock speed of the DC-DC converter is 80 kHz.

	Generated voltage	Maximum current
Internal supply servo section logic	+5 V ± 0.2 V	1 A
Internal supply servo section analog	+15 V ± 0.4 V	1 A
Internal supply servo section analog	-15 V ± 0.4 V	1 A
Internal supply measuring section logic	+5 V ± 0.2 V	1 A
Transducer excitation	+12 V ± 0.2 V	0.6 A
Transducer excitation	-12 V ± 0.2 V	0.2 A
Supply of ARCNET output level	+5 V ± 0.2 V	0.2 A

Motor Output Section

- Short-circuit protected: phase - phase, phase - PE (earth ground), phase - temperature
  monitoring.
- Overvoltage protection
- Minimal loss due to IGBT output section.
- Very good heat dissipation; the entire housing serves as heat sink.
- Integrated, electronically monitored brake chopper allows dissipation of brake energy through the internal brake resistors.

	TM12		TM34	
Nutrunner spindle type	1B..	2B..	3B..	4B..
Intermediate circuit voltage Uz	320 VDC ± 10 %			
Error shut-down at	UZ < 150 VDC, UZ > 400 VDC			
Rated output at 50° C	200 VA	400 VA	800 VA	800 VA
Temporary peak output	1200 VA	2000 VA	2000 VA	3500 VA
Adjusted peak current	9 A	22 A	34 A	66 A
Short-circuit current shut-off	50 A	50 A	100 A	100 A
Efficiency	97 %	97 %	97 %	97 %
Power loss at rated nutrunner output	4 W	11 W	19 W	19 W
Clock speed of PWM	10 kHz			
Maximum temporary brake output	4000 VA		7200 VA	

Power Loss

- Low power loss components limit heat radiation.
- The high admissible operating temperature of 50 °C reduces the need for additional cooling measures in many cases.
- The position of the brake resistors ensures that no other components of the TM are influenced by the heat dissipated by them.

	TM12		TM34	
Nutrunner spindle type	1B..	2B..	3B..	4B..
Total power loss at rated output of nutrunner spindle	28 W	35 W	43 W	43 W

Calculation of Temperature to be Expected inside Control Cabinet

To ensure safe operation and reach the service life of 20,000 hours, the TM must be operated in
a control cabinet with a maximum inside temperature of 50 °C.

The temperature to be expected inside the control cabinet must be calculated when the cabinet is designed..

Formula:

$$Ti = Tu + \frac{Pv_{TM\ tot} + Pv_{additional\ heat\ sources}}{A \times k}$$

Ti	= Temperature to be expected inside control cabinet (in °C)
Tu	= Ambient temperature (room temperature in °C)
$Pv_{TM\ tot}$	= Overall power loss of all TMs (in W) From the intermediate circuit of the logic section
$Pv_{additional\ heat\ sources}$	= Power loss of all additional heat sources installed inside the control cabinet (in W)
A	= Effective cabinet surface (in m2) All free cabinet surfaces
K	= Heat transition coefficient of sheet metal = 5.0 (W/m^2K)

CAUTION!

At a calculated inside temperature (Ti) above 50° C additional cooling measures, such as an air conditioner or heat exchanger, are required.

Measuring Board

• The measuring board is part of the TM and must not be replaced individually.
• It has separate processors for measuring and communication tasks, angle tracing and ARCNET**Error! Bookmark not defined.**.
• Separate 5 V supply**Error! Bookmark not defined.**.
• The measuring software is saved in a FLASH EPROM, reload is carried out via ARCNET
from the station controller.
• Reset via servo amplifier or station controller (warm start).
• Two separate measuring channels for torque and angle tracing (2 tracks each).
• Polling rate 5000 measurements per second.
• Resolution 12 bit at ±10 V.
• Analog filter for torque measuring signals 1 kHz.
• Maximum angle frequency 9 kHz, corresponds to 1500 revolutions per minute at the output
attachment of the nutrunner spindle, at a resolution of 1 pulse per degree.
• Acquisition of motor angle signals transmitted by the servo amplifier via Dual-Port-RAM.
These are generated from the resolver signals.
• Acquisition of the motor current transmitted by the servo amplifier (via DPR).

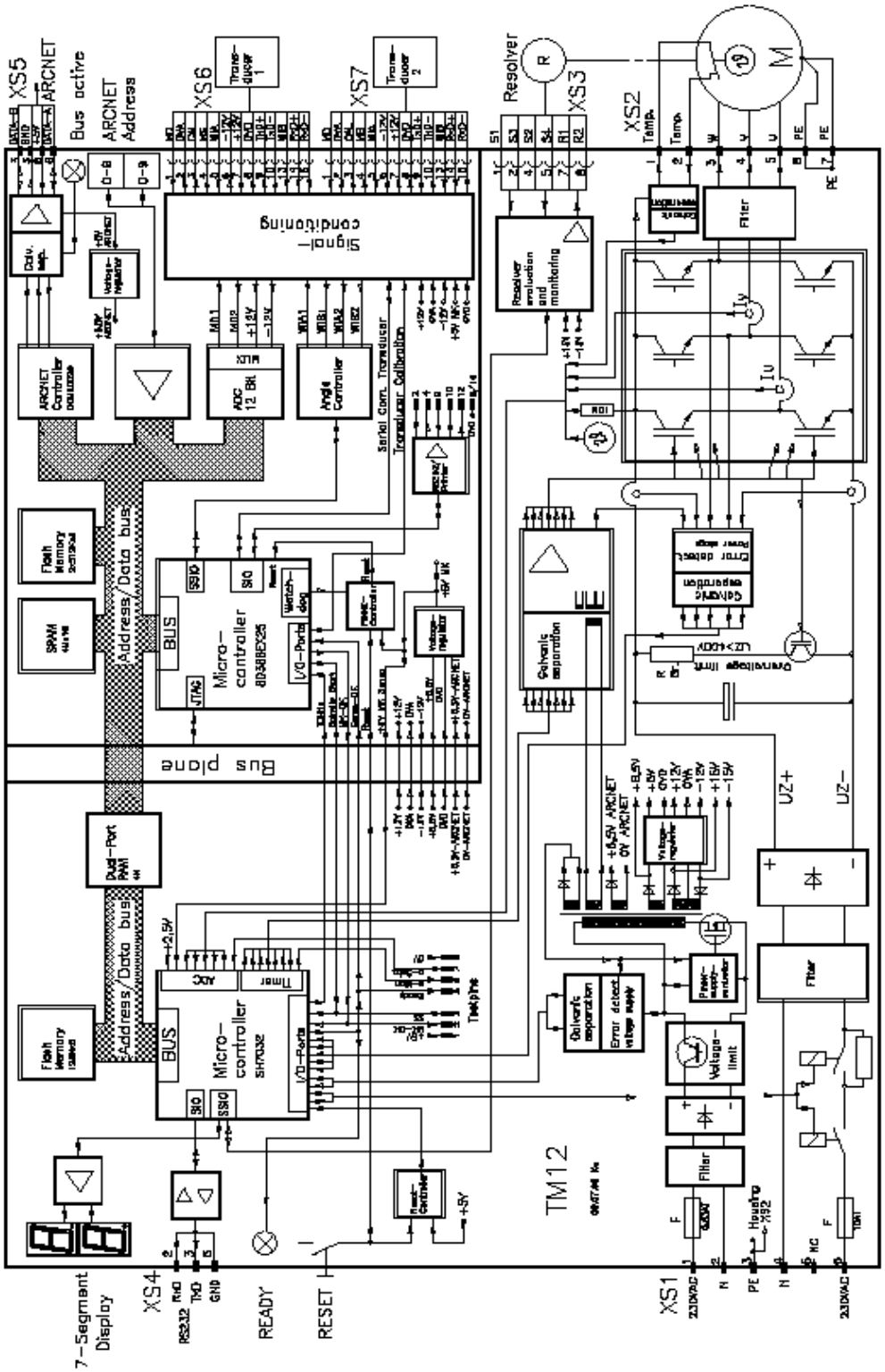
Communication between Measuring Board and Servo Amplifier Section

• A Dual-Port-RAM (DPR) is used for communication between servo amplifier and measuring board.
• For safety reasons, the start signal is transmitted via a direct line as well as via the Dual-Port-RAM from the measuring board to the servo amplifier section.

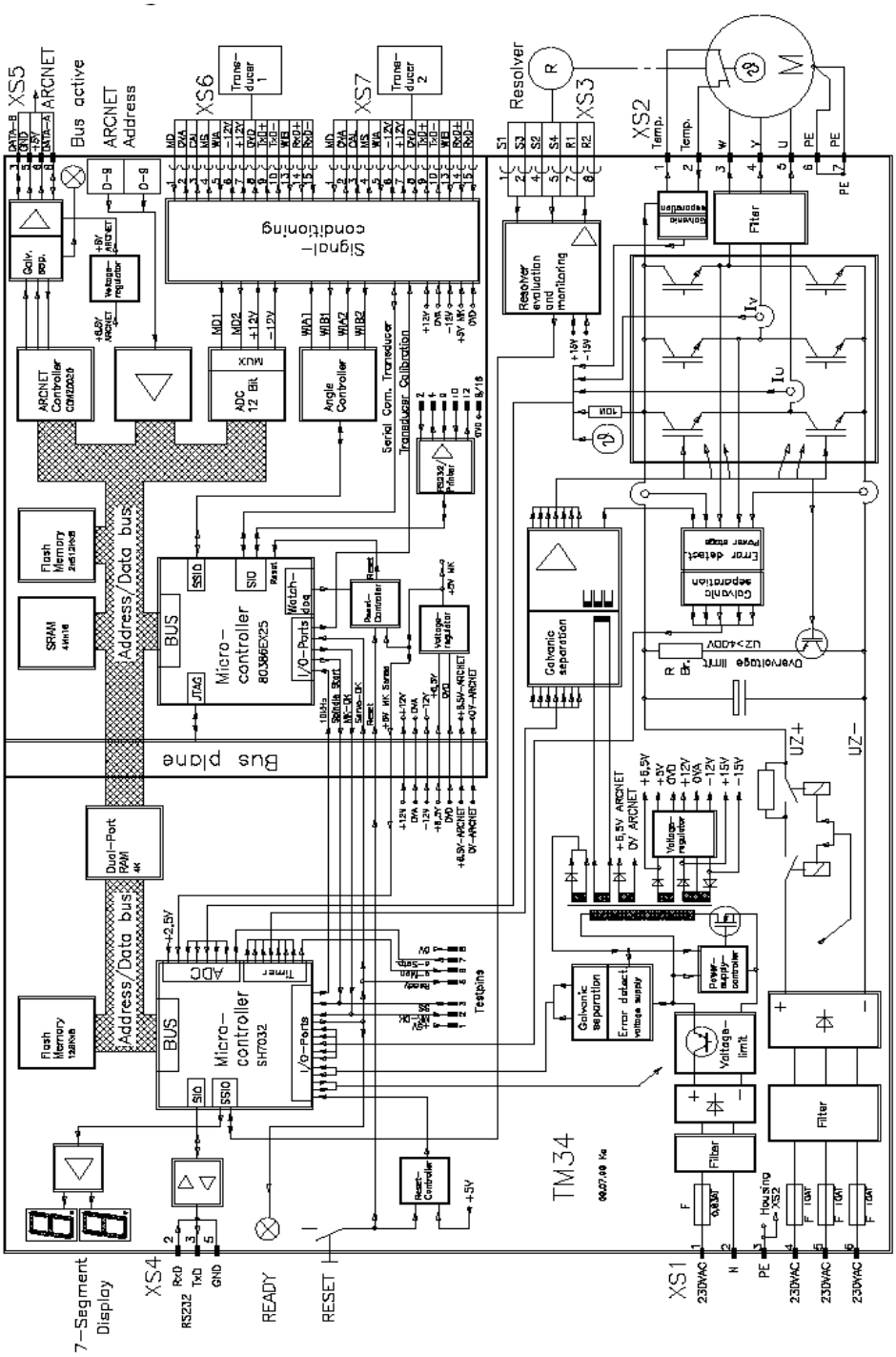
Communication between Measuring Board and Station Controller

• Communication is made via the high-performance field bus ARCNET.
• Transmission speed is 2.5 MBd.
• Maximum network distance 100 m.
• Star and tree topologies are possible with bus amplifier module HUB (Cooper Tools Ident No. 960920).
• Twisted and shielded two-wire cable (RS485).
• Bus termination at beginning and end of chain by bus termination adapter (Cooper Tools Ident. No. 960951) and bus termination (Cooper Tools Ident No. 960959).
• Use only Cooper Tools ARCNET cables with Ident No.: 960950-XXX (XXX=length in m).

Block Diagram TM12



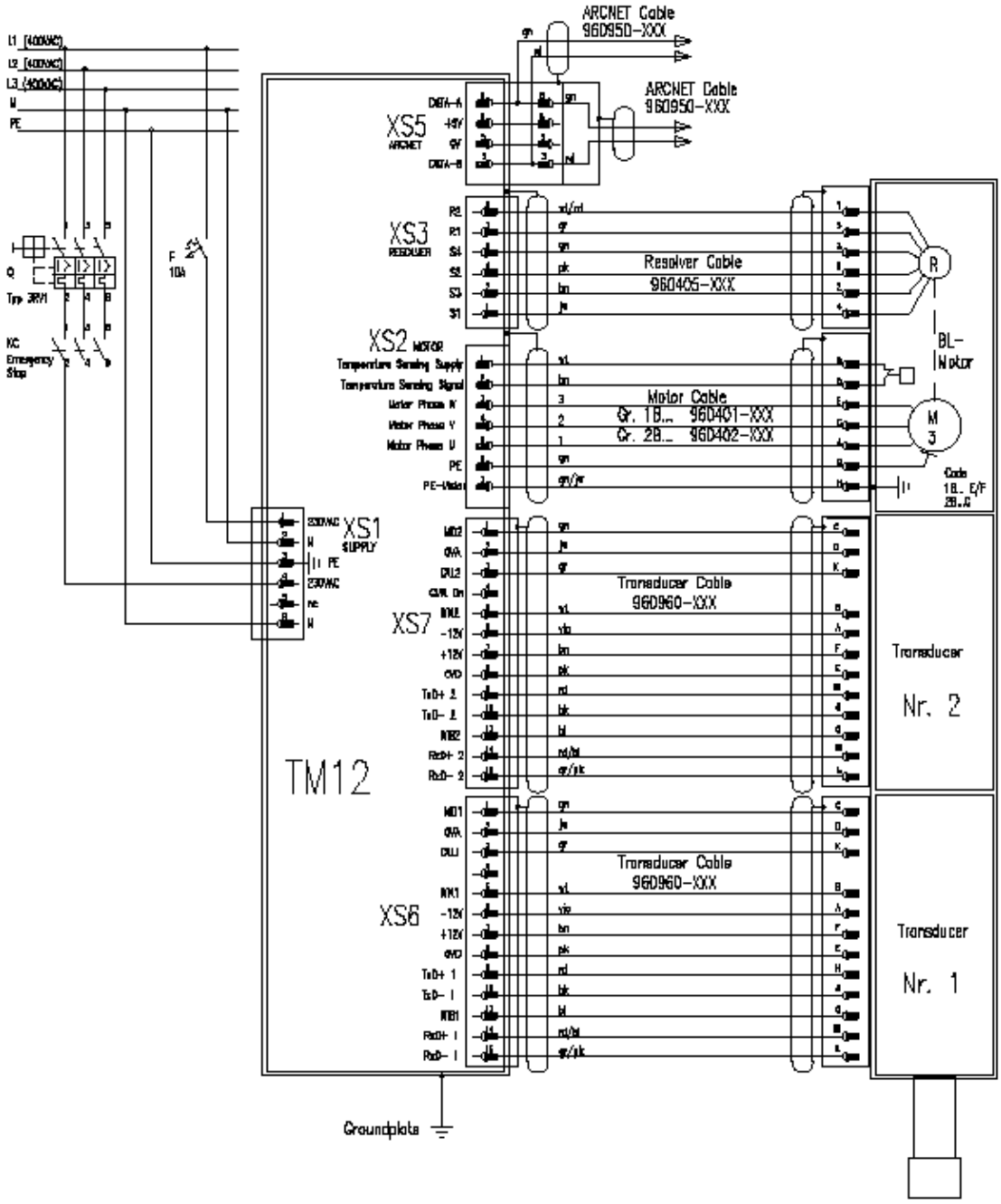
Block Diagram TM34



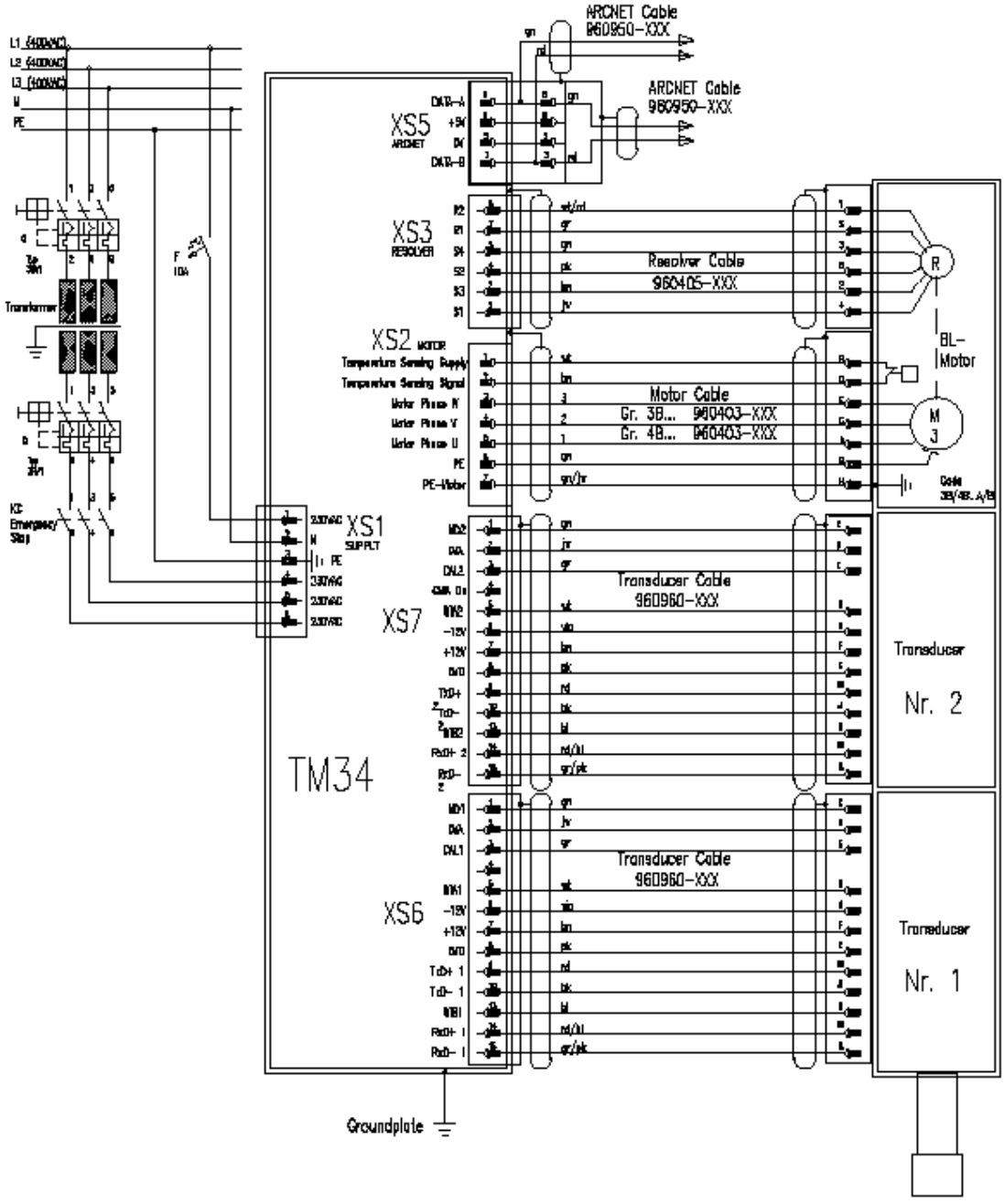
Explanation of Terms

ADC	analog - digital converter
Address	address, channel number
Angle Controller	processor for angle processing
ARCNET	network (field bus)
Bus plane	bus circuit board
Display	display
Error detect	error detection
voltage supply	voltage supply
Filter	filter suppressing EMC interference
Galvanic separation	galvanic separation
Galv. sep.	galvanic separation
Housing	housing
MK	measuring board
MUX	multiplexer
Overvoltage limit	overvoltage limit
Power Stage	output section
Power supply controller	power supply controller
Resolver	motor position tracing
Resolver evaluation	resolver evaluation
RS232/Printer	serial printer interface (internal)
Serial Com. Transducer	serial data transmission to combined transducer
Signal conditioning	signal conditioning
Temp.	motor temperature
Test pins	internal test connections
Transducer and monitoringn	combined transducer for torque and angle and monitoring
Transducer Calibration	calibration signal for combined transducer
Voltage limit	voltage limit
Voltage regulator	voltage regulator

Block Diagram TM12



Block Diagram TM34



Connections

• All plug in connections are located on the front of the TM.
• All connections, except "XS1 Supply", can be secured from unintentional unplugging with
screws or slide locks.
• The connections for motor, resolver and transducer are compatible with the m-Pro-400 fastening
system with measuring board S torque and servo amplifier BLS.

CAUTION!

It is prohibited:

- **To operate the TM and the nutrunner spindle without PE (protected earth ground) connections! Fatal electric shock may occur.**
- **To use other connector types.**
- **To use cables other than those approved by Cooper Tools.**
- **To connect fastening spindles and motors not made by Cooper Tools.**

"Supply XS1"

• The connector coding ensures that the plug for XS1 cannot be plugged into XS2.

Type: PHOENIX Power-Combicon PC4/6-7,62
Cooper Tools Id. No.: 960942 (incl. coding on pin 1)

Pin	Type	
	TM12	TM34
1	Supply of intermediate circuit of logic section (logic power supply) L1 (230 (VAC)	
2	Supply of intermediate circuit of logic section (logic power supply) N	
3	PE	
4	Supply intermediate circuit of the power section L 1 230 VAC	Supply intermediate circuit of the power section L 1 230
5	NC	Supply intermediate circuit of the power section L 2 230
6	Supply intermediate circuit of the power section N (230 VAC)	Supply intermediate circuit of the power section L 3 230

It is prohibited to remove the coding on the power connector plug or on the TM. If the plugs are confused, the TM can be destroyed.

The TM must be fastened to a zinc plated and earth grounded mounting plate.

High discharge current: connect earth ground before servicing!

"Motor XS2"

• The connector coding on pin 1 and 2 ensures that the plug of XS1 cannot be plugged into
XS2.
• Cable breakage monitoring
• Integrated filtering of motor outputs.

Type: PHOENIX Power-Combicon PC4/7-7,62

Pin	Type	
	TM12	TM34
1	Motor temperature monitoring supply	
2	Motor temperature monitoring supply	
3	Motor phase W	
4	Motor phase V	
5	Motor phase U	
6	PE (protected earth ground)	
7	PE (protected earth ground)	

The motor phases and the lines of the thermal switch must not be touched, even if the TM is in failure mode.
Fatal electric shock may occur.

"Resolver XS3"

• All resolver signals are short-circuit protected, also to PE (protected earth ground).
• Cable breakage monitoring 9 pole D-Sub socket with lock screws, 4-40 UNC threads.

Type: 9 pole D-Sub socket with lock screws, 4-40 UNC threads.

Pin	Description	Input/Output	Signal Level
1	S1 cosine signal	Input	
2	S3 cosine signal	Input	0 V
3,6		nc	
4	S2 sine signal	Input	
5	S4 sine signal	Input	0 V
7	R1 carrier signal	Output	11 Vpp, 10 kHz
8	R2 carrier signal	Output	0 V
9	Connected to PE (protected earth ground)		
Housing	Shield connection PE (protected earth ground)		

⚠ **It is prohibited to short circuit the lines or connections of the resolver, the interface RS232, the ARCNET, and the transducers to the supply, motor line, or the temperature contact of the motor. The TM will be destroyed.**

Service Interface "RS232 XS4"

- Service PC interface via null modem cable (Cooper Tools Id. No.: 960007).
- Short-circuit protected

Type: 9 pole D-Sub pins with lock screws, 4-40 UNC threads.

Pin	Description
2	RxD
3	TxD
5	GND
1,4,6,7,8,9	Nc
Housing	Shield connection PE (protected earth ground)

- Short-circuit protected
- Galvanic separation from all other functional assemblies of the TM.

Type: 9 pole D-Sub pins with slide lock systems Inotec

Pin	Description
1	PE
2,4,7,9	Nc
3	DATA-B

5	GND (ARCNET)
6	+5 V (ARCNET)
8	DATA-A
Housing	Shield connection PE (protected earth ground)

Transducer No. 1 "XS6" Controlling Transducer
Transducer No. 2 "XS7" Redundant Transducer for Cross-checking

• Short-circuit protected
Type: 15 pole D-Sub socket with lock screws, 4-40 UNC threads.

Pin	Description	Output/Input	Signal level/data
1	Measuring signal	Analog input	-5…+5 V, (measuring range –6.25…+6.25)
2	Supply analog 0V	Output	0 VA
3	Calibration signal	Output	+5 V (±0.5 V), I_{max} = 15 mA
4	Cross-checking adapter on	Output	+5 V (±0.5 V), Ri=500Ω
5	Angle track 1	Input	0…5 V = 0.7…12 v = 1, pull-up 1 kΩ
6	Supply -12 V	Output	-12 V (±0.2 V), I_{max} = 100 mA
7	Supply +12 V	Output	+12 V (± 0.2 V), I_{max} = 200 mA
8	Supply digital 0 V	Output	0 VD
9	Interface RS422 TxD+	Output	5 V, Ri = 500 Ω
10	Interface RS422 TxD-	Output	0 V, Ri = 500 Ω
11	Nc		
12	Nc		
13	Angle track 2	Input	0…5 V=0.7…12 V=1, pull-up 1 kΩ
14	Interface RS422 RxD+	Input	
15	Interface RS422 RxD-	Input	
Housing	Shield connection PE (protected earth ground)		

Operating Elements

"RESET" Button

- Processor reset for all internal functions of the TM.
- Used to acknowledge failures.
- Pressing results in reconfiguration of all functions.

Selector Switch for ARCNET "Address"

- Adjusts ARCNET address.
- BCD-code switch, upper switch for tens digit (**0**0-**9**0), bottom switch for ones digit (0**0**-0**9**).
- Admissible settings 01 to 32.
- Adjust only when supply is switched off.
- If two or more modules have the same address, the error code 50 is output.
- The address adjustment can be checked upon power-up or reset at the two-digit 7-segment display.

Displays

Status and Diagnosis Display

- Red 7-segments two-digit.
- Operating conditions and error codes (flashing) are displayed.

Operating conditions

Upon power-up or reset the following messages are displayed:

- Lamp test, that is, all 2 x 7 segments are on (**88**) for 1 second. Then the display is off for approx. 0.5 seconds.
- The adjusted ARCNET address, is displayed as **01 - 32** for 1 second. Then the display is off for approx. 0.5 seconds.
- Selected motor - control parameter set will be shown on the bottom display (on TM12 a "**1**" or a "**2**" will appear, on TM34 a "**3**" or a "**4**", will appear for 1 second; while the upper display will not be on.

During fastening operation:

- Display during fastening **11 - FF**
  The top display shows the selected fastening program.
  The bottom display shows the selected fastening stage.
- Overload, display **IP**

If current above the maximum admissible current is drawn during a fastening cycle, the
servo amplifier shuts-off automatically and IP is displayed.
The overload error is reset by a restart.
Im test operation controlled by station controller
• drive active, top display **A**, bottom display not on

LED"READY"
• Color green.
• Indicates ready to operate condition of the TM.
• If all supply voltages are present and no failure is present, this LED is on

LED "Bus active"
• Color green.
• Displays ARCNET bus activity.
• If data is being transferred on the ARCNET bus, this LED is on

Troubleshooting

To allow fast diagnosis of errors, LEDs and a two-digit 7-segment display are installed on the
front panel.

Display of Errors

- The errors are shown as codes. The display **00 - 99 flashes** at a frequency of approx. 1 Hz.
- If an error occurs in the TM, in the main power supply, in the motor, in the transducers
  or in the ARCNET, the error codes listed in the table below are immediately triggered.
- If several errors occur at the same time, the failure with the highest priority, that is
  the lowest number, is displayed.
- Exceptions:
  - Error **64** "Torque- +12 V NOK"
    has priority over **15, 16, 17, 21, 22, 28, 40** and **41** (description see table).

Error **65** "Torque- -12 V NOK"
has priority over **15, 16, 17, 28** and **40** (description see table).
- The failure **40** "Torque is not ready" has the lowest priority, since the errors **41** to **FF** cannot
be described as a common error (**40**) to simplify error diagnosis.
• All errors are reported to the station controller via the ARCNET and are then displayed on its
monitor.

In the rundown data table the abbreviations "**FLT, F Torque, AN1F, AN2F, OFF1, OFF2,...**"
are shown in the "ERROR" column.
In the rundown data table the window "Spindle monitor" opens.
When the soft key "i" is pressed the error list is opened and all current errors are displayed as
descriptive text.

Acknowledging errors

• When the error has been resolved, press the RESET button to return the TM to the ready
condition.
• Upon each spindle start, the measuring board sends an acknowledgement signal to the output
section.
If the error is momentary only (e. g. undervoltage), the TM automatically returns to the ready
state after the next acknowledgement signal.
Since all errors are archived by the station controller, the error information can be displayed
for troubleshooting. However, the display of the TM does not flash anymore once an error
has been acknowledged.

When measuring continuity, impedance or checking for a short-circuit in the motor or motor cable, be sure to disconnect these from the TM. Fatal electric shock may occur.

DISPLAY 88 Top Display Bottom Display Error Explanation		Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
00	**Supply DC/DC converter undervoltage** Supply DC/DC converter undervoltage < 150 VAC	X	X	X		• Measure supply voltage If < 200 VAC increase to 230 VAC • If errors occur sporadically, check the supply for voltage drops
01	**Supply DC/DC converter overvoltage** The voltage of the intermediate circuit of logic section is > 440 VDC	X		X		• Measure supply voltage If > 225 VAC decrease to 230 VAC • If errors occur sporadically, check the supply for voltage overshoot
02	**Intermediate circuit of the power section** Not supplied	X	X		X	• Check supply (prefusing of TM, EMERGENCY STOP contactor, etc.)
11	**Motor cable defective** • Cable in motor lines broken • Motor phases interrupted • Test current of cable monitoring misguided	X	X	X		• Motor connected? • Check motor cable for continuity and short-circuit • Check motor for short-circuit to PE and check phase impedance (1B.. approx. 25 Ω, 2B.. approx. 8 Ω, 3B.. approx. 2 Ω, 4B.. approx. 1 Ω)
12	**Short-circuit in motor circuit** • in cable • in motor • in TM.	X	X	X		• Check motor cable for short-circuit, • Check motor for short-circuit (phase impedances see failure 11)

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay off	Output Section Off	Brake Motor, Output Section Off	
13	**Motor temperature too high** • Thermal switch in motor tripped (ϑ > 120°C) • Measuring line broken • Measuring current misguided • Motor not connected	X	X	X		• Motor connected? • Check motor temperature, if > 80°C, ensure sufficient ventilation of motor • Check motor cable for continuity and short-circuit • Check continuity of motor thermal switch • Internal error, replace TM
14	**I^2t monitoring** • Required motor output is too high • Nutrunner is defective (e.g. gearing, bearing)	X		X		• Check motor temperature, if > 80°C, decrease fastening time by increasing the speed • Replace motor / nutrunner • Internal error, replace TM
15	**Resolver error** The resolver signals are • interrupted • shorted • not present The internal +/- 12 V power supply is • shorted	X		X		• Resolver connected? • Check resolver cable for continuity and short-circuit • Replace motor • Check transducer cable, especially +/- 12 V and 0 V conductors • Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
16	**Intermediate circuit voltage too high** The voltage of the intermediate circuit of the power section is > 400 VDC	X	X	X		Permanent error: • Measure supply voltage If > 255 VAC, reduce to 230 VAC During braking: • Capacitors in intermediate circuit are open • Brake chopper is defective, replace TM Sporadically: • The supply voltage is too high sporadically; if transformer is available, connect next higher tap • Internal error, replace TM
17	**Intermediate circuit voltage too low** The voltage of the intermediate circuit is < 150 VDC	X	X		X	Permanent error: • Measure supply voltage if < 200 VAC increase to 230 VAC During fastening: • The supply is too “weak” or overloaded, ensure more stable supply (e.g. larger transformer) • Capacitors in intermediate circuit are open, replace TM • On TM34: one phase missing • Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	n 2 Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
20	**Temperature in output section too high** The temperature in TM is > 80°C	X	X	X		• Measure temperature inside cabinet below TM, if ϑ > 50°C, additional cooling (e.g. air conditioner) required. • Cooling slots of TM must not
21	**Start-up relay does not open** Due to an internal error, the contact in the start-up relay sticks.	X	X	X		• Internal error, replace TM
22	**Main relay does not open** Due to an internal error, the contact in the main relay sticks.	X	X	X		• Internal error, replace TM
25	**5 V supply in servo too low** The 5 V power supply for internal supply of the servo amplifier is overloaded. U < 4.8 VDC	X	X	X		• Internal error, replace TM
26	**5 V supply in servo too high** The 5 V power supply for internal supply of the servo amplifier is defective. U > 5.2 VDC	X	X	X		• Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
27	**Driver supply of output section too low** The power supply for internal supply of the output section is overloaded or defective.	X	X	X		• Internal error, replace TM
28	**Offset of current measurement too high** The zero-point of the integrated motor current measurement has been shifted.	X	X	X		• Internal error, replace TM
30	**5 V supply in measuring board too low** The power supply for internal supply of the measuring board is overloaded or defective. U < 4.8 VDC	X			X	• Internal error, replace TM

31	**5 V supply in measuring board too high** The 5 V power supply for internal supply of the measuring board is defective. U > 5.2 VDC	X			X	• Internal error, replace TM
32	**DPR error servo** The Dual-Port-RAM for communication between servo and measuring board is defective.	X			X	• Internal error, replace TM
33	**Flash error servo** The flash memory is defective	X	X	X		• Internal error, replace TM
34	**DPR communication to torque interrupted** The Dual-Port-RAM communication between servo and measuring board is failing.	X			X	• Internal error, replace TM

DISPLAY 88 Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
	LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
35 **Start signal sequence faulty** Communication error between measuring board and servo amplifier	X			X	• Internal error, replace TM • Inform Cooper Tools service department
38 **MOTID error** Error in motor identification mode	X		X		• Internal error, replace TM
39 **Mathematic error illegal command etc.** Error in program processing	X		X		• Internal error, replace TM • Inform Cooper Tools service department
40 **Measuring board not ready** The signal “measuring board OK” is not received by the servo section	X			X	• Measuring board present? • Measuring board firmly secured to TM? • Internal error, replace TM
50 **ARCNET multiple address** The address adjusted on this TM already exists.					• Check addressing, that is switch settings of ARCNET, each client must have a unique address. • Internal error, replace TM
51 **ARCNET address faulty** The selected address is not in the permissible range.					• Change address to be in the range between 01 and 32. • Internal error, replace TM

52	**ARCNET Error** Communication error					Check ARCNET: • Bus terminators installed? • Are the clients with the bus terminations switched on? • All cables plugged in? • Check addressing of ARCNET, that is, switch settings. • Internal error, replace TM • Inform Cooper Tools service department

DISPLAY 88 **Top Display** **Bottom Display** **Error Explanation**		**Consequence**				**Measures, Remedy**
		LED-Ready off	**Main and Startup Relay**	**Output Section Off**	**Brake Motor, Output Section Off**	
53	**ARCNET Recon** To many reconfigurations, network is unstable					Check ARCNET: • Bus terminators installed? • All ARCNET cables plugged in? • Check addressing of ARCNET, that is, switch settings • Are the clients with the bus terminations switched on?
54	**ARCNET – not connected to network** The TM is not connected to the ARCNET.				X	Check ARCNET: • Bus terminators installed? • Are the clients with the bus terminations switched on? • All cables plugged in

						• Internal error, replace TM
61	**Torque measuring card parameters are wrong** Fastening parameters in measuring board are NOK					Check programming of station controller: • Spindle constants • Calibration values • Fastening strategy (SEQ) • Fastening stage • Parameter set
62	**Torque – Memory overflow** Not enough RAM storage available					• Inform Cooper Tools service department • Internal error, replace TM
64	**Torque- +12 V NOK** The +12 V supply of the measuring board is out of tolerance limits between +11.4 V… +12.6 V	X		X		Check at station controller in test mode, the value out of tolerances: • Check transducer cable, especially the +12 V and 0 V conductors • Check resolver cable for short-circuit • Replace transducer • Replace motor • Internal error, replace TM

DISPLAY 88 Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
	LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
65 **Torque- - 12 V** The –12 V supply of the measuring board is out of tolerance limits between –11.1 V… -12.9 V	X		X		Check at station controller in test mode, the value out of tolerances: • Check transducer cable, especially the –12 V and 0 V conductors • Check resolver cable for short-circuit • Replace transducer • Replace motor • Internal error, replace TM
66 **Torque– Process Control** Process sequence - start stage - graphics not adhered to					• Inform Cooper Tools service department • Internal error, replace TM
68 **Torque – Initialization NOK** Initialization error in measuring board					• Inform Cooper Tools service department • Internal error, replace TM
69 **Torque – access to DPR NOK** The measuring board cannot access the DPR in the servo					• Inform Cooper Tools service department • Internal error, replace TM
6A **Torque – servotype not TM12/34** The TM type read by the measuring board is unknown			X		• Internal error, replace TM

6 C	**Torque– no cycle signal from servo** The synchronization signal between servo and measuring board is not present			X		• Measuring board firmly secured to the TM? • Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
6E	**Torque – servo parameters do not fit servo** The parameter set selected by the measuring board is not available in the TM.			X		• Check programming of system • Internal error, replace TM
71	**Transducer 1 not present** The transducer signal is • Interrupted • Shorted • Not present					• Is the transducer connected? • Check transducer cable for continuity and short-circuit • Replace transducer • Internal error, replace TM
72	**Transducer 1 Offset NOK** The zero-point voltage is out of the admissible range between –200 mV… +200 mV					• Transducer installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace transducer • Internal error, replace TM

73	**Transducer 1 calibration voltage NOK** The calibration voltage is out of the admissible range between +4.85 V… +5.15 V					• Transducer installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace transducer • If deviation is extreme check transducer cable, especially the calibration line • - Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	n 3 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
74	**Transducer 1 angle tracing NOK** The angle signals are • interrupted • shorted • not present • not present part of the time					Check at the station controller If no angle signals are detected in testmode: • Check transducer cable especially the angle lines Spindle rotates more than 360 degrees: • Check angle factor • Replace transducer • Internal error, replace TM
75	**Transducer 1 rundown counter NOK** The rundown counter in the transducer does not work, the maximum number of rundowns for the transducer have been exceeded. Only on transducers with service memory (e.g. 1K1M).					• Check transducer cable, especially the RS422 data lines • Replace transducer • Internal error, replace TM
76	**Transducer 1 rundown counter at limit** The rundown counter in the transducer has reached its maximum number of rundowns of 107, or it is defective. Only on transducers with service memory (e.g. 1K1M).					• Replace transducer

81	**Transducer 2 not present** The transducer signal is • interrupted • shorted • not present					• Is the transducer connected? • Check transducer cable for continuity and short-circuit • Replace transducer • Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	n 4 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
82	**Transducer 2 Offset NOK** The zero-point voltage is out of the admissible range between –200 mV… +200 mV					• Transducer installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace transducer • Internal error, replace TM
83	**Transducer 2 calibration voltage NOK** The calibration voltage is out of the admissible range between +4.85 V.. +5.15 V					• Transducer installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace transducer • If deviation is extreme, check transducer cable, especially the calibration line • Internal error, replace TM
84	**Transducer 2 angle tracing NOK** The angle signals are • Interrupted • Shorted • Not present • Not present part of the time					Check at the station controller If no angle signals are detected in test mode: • Check transducer cable especially the angle lines Spindle rotates more than 360 degrees: • Check angle factor • Replace transducer • Internal error, replace TM

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
85	**Transducer 2 rundown counter NOK** The rundown counter in the transducer does not work, the maximum number of rundown for the transducer have been exceeded. Only on transducers with service memory (e.g. 1K1M).					• Check transducer cable, especially the RS422 data lines • Replace transducer • Internal error, replace TM
86	**Transducer 2 rundown counter at limit** The rundown counter in the transducer has reached its maximum number of rundowns of 107, or it is defective.					• Replace transducer
90	**Torque – exception** Error in program processing					• Internal error, replace TM • Inform Cooper Tools service department
92	**Torque – General initialization error** Initialization of internal communication interfaces is NOK					• Internal error, replace TM • Inform Cooper Tools service department
93	**Torque – communication error** Communication interfaces are NOK					• Internal error, replace TM • Inform Cooper Tools service department
96	**Servo not OK** Ready signal from servo is not present					• Measuring board firmly secured to TM? • Internal error, replace TM
98	**Flash error** Program update not possible The station controller is trying to send a faulty program					• Check program selection • Internal error, replace TM • Inform Cooper Tools service department

9 **9**	**Task ID error** Software monitoring					• Internal error, replace TM • Inform Cooper Tools service department

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
IP	**Overload (not flashing)** If a current above the admissible maximum current is drawn during fastening, the servo amplifier shuts-off automatically. • Error in motor position tracing, e.g. resolver, cable • Error in motor circuit e.g. motor does not reach required torque					Check system programming: • Nutrunner selection • Required torque Check motor position tracing: • Check resolver cable and replace motor • Internal error, replace TM • Check motor cable • Replace motor

LED's "READY" and "Bus active"

Error	Measures, Remedy
n 5 **LED "READY" not on** The TM is not ready 7-segment display flashes	• Check supply voltages • Internal error, replace TM Refer to Display of Errors

LED "Bus active" flashes at approx. 1 Hz frequency ARCNET – communication interrupted **LED "Bus active" not on** Status and diagnosis display flashes	Check ARCNET connection: • Check all connector locks • Check ARCNET cable for continuity and short-circuit • Internal error, replace TM • Refer to Display of Errors

SECTION 16

TM Servo Module for Handtools
TMH 960902

General Information

General Description of Tightening Modules TMH

• In the tightening module "TMH" the servo amplifier (output section) and the measuring section
(measuring board Torque) are integrated in one housing.
• The difference between the TM12/TM34 and the TMH is the special adaption of the software
in the servo amplifier and the measuring board of TMH to handheld tools.
• There are separate processors for measuring and output section.
• Motors are controlled digitally.
• The control parameters for different motors or hand tools are saved permanently in the TMH
and are selected by the measuring board.

Field of Application

• The tightening module has been designed to operate Cooper Tools handheld angle nutsetters
- 17E..
- 47E..
- 67E..
• The tightening module is used in conjunction with the station controller m-Pro-400 Touch-
screen.
• The TMH communicates with the station controller "m-Pro-400 Touch-screen" via a serial high-speed FieldBus ARCNET.
Thus decentralized arrangement of station controller and TMHs at a distance of up to 100 m is possible.

Service

• TMH can be replaced without requiring calibration.
The station controller m-Pro-400 Touch-screen transmits all settings and adjustments
automatically to the new TMH.
• Fast, precise diagnosis in case of failures is facilitated by displayed text at the station controller
and coded messages displayed on a 2-digit 7-segment display at the TMH
• If the housing is opened, the warranty is voided.
• The TMH must always be replaced in its entirety.

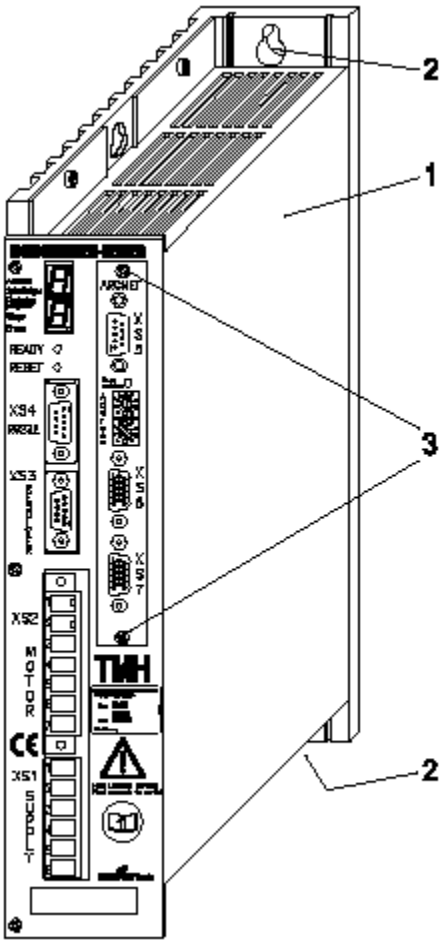
Transport and Storage

- Only transport the device in the original packing.
- The packing is recyclable.
- If the packing is damaged, check the TMH for visible signs of damage. Inform the carrier and Cooper Tools if required.

Mechanical Properties

Description

- Rugged metal casing. **-1-**
- Fastening with M6x20 cap screws to the mounting plate of the control cabinet, through key holes in the TMH. **-2-**
- The measuring board can be plugged in and out and is fixed with two screws in the hood. **-3-**



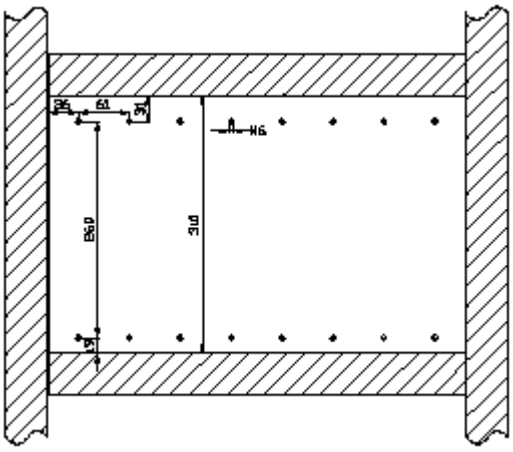
Data

	TMH	
Height	280 mm	
Width	60 mm	
Depth	200 mm	
Maximum depth with plugs	280 mm	
Spacing of mounting holes	260 mm center to center	
Weight	3400 g	3420 g
Enclosure type	IP20	
Type of cooling	Convection (self-cooling)	
Ambient temperature	0…50° C	
Storage temperature	-20…60° C	
Humidity	0…90 % non-condensing	
Service life in operating	20,000 h	
Usability for storage	100,000 h (approx. 11 years)	

Installation Guidelines

- A closed steel plate control cabinet must be used.
- A zinc plated mounting plate must be used; it must not be painted.

Drilling sketch



Electromechanical Properties

- All connections are located at the front.
- Two transducers can be connected (redundant setup of measuring sensors according to VDI 2862).
- Fast error diagnosis with 2-digit 7-segment display.
- Current fastening stage and parameter set are displayed by 2-digit 7-segment display.
- LED "READY" indicates ready to operate condition.
- "RESET" button
- Cooper Tools service interface RS232
- ARCNET Addressing with 2 BCD switches.
- LED for ARCNET bus activity.
- The cable shields for the resolver cable between the TMH and the connector board are connected to the housing with shield connecting components (Cooper Tools Ident No. S960434 and S960435).
- All connectors and housing openings are contact protected (IP20).

Electric Data

Power Supply

The intermediate circuits of the power section and the logic section are supplied separately. This
allows separate power-down of the intermediate circuit of the power section upon EMERGENCY
STOP.
The logic power supply unit and therefore all communication assemblies continue to be supplied.

CAUTION!

The internal fuses protect the conductor tracks inside the TMH if defects occur or if the external fusing is too high.
The fuses must only be replaced by Cooper Tools.

Intermediate Circuit of the Power Section

- Integrated starting current limit by two processor-controlled relays.
  The main relay is switched on after the initialization.
  The intermediate circuit capacitors are charged through a starting current limiting resistor,
  until a voltage of approx. 300 VDC is reached. Thereafter the resistor is bridged by the startup
  relay.
- The TMH must be operated on an isolation transformer approved by Cooper Tools.

Connector XS1

	TMH	
Handtool type	**17E…**	**47E/67E**
Supply voltage	1 X 230 VAC ± 10 %	
Frequency	50-60 Hz	
Rated supply current RMS	0,5 A	1 A
Peak supply current RMS	8 A	16 A
Internal fusing (slow blow)	10 A	
Starting current limit	5 A	

Intermediate Circuit of Logic Section

• All logic voltages and supply voltages for the communication functions are generated from
the intermediate circuit of the logic section.

Connector XS1

	TMH
Supply current	1 X 230 VAC ± 10 %
Frequency	50-60 Hz
Rated supply current	Ca. 0, 1 A
Internal fusing (slow blow)	0, 63 A
Power loss (standby)	24 W

Internal Power Supply Units

- Supplied by the intermediate circuit of the logic section, galvanically separated.
- All generated voltages are short-circuit protected.
- The ARCNET output level is galvanically separated from all other supplies.
- The clock speed of the DC-DC converter is 80 kHz.

	Generated voltage	**Maximum current**
Internal supply servo section logic	+5 V ± 0.2 V	1 A
Internal supply servo section analog	+15 V ± 0.4 V	1 A
Internal supply servo section analog	-15 V ± 0.4 V	1 A

Internal supply measuring section logic	+5 V ± 0.2 V	1 A
Transducer excitation	+12 V ± 0.2 V	0.6 A
Transducer excitation	-12 V ± 0.2 V	0.2 A
Supply of ARCNET output level	+5 V ± 0.2 V	0.2 A

Motor Output Section

- Short-circuit protected: phase - phase, phase - PE (earth ground), phase - temperature monitoring.
- Overvoltage protection
- Minimal loss due to IGBT output section.
- Very good heat dissipation; the entire housing serves as heat sink.
- Integrated, electronically monitored brake chopper allows dissipation of brake energy through the internal brake resistors.

	TMH	
Handtool type	**17E…**	**47E/67E…**
Intermediate circuit	320 VDC ± 10 %	
Error shut-down at	UZ < 150 VDC, UZ > 400 VDC	
Rated output of tool at 50°	40 VA	60 VA
Temporary peak output	1200 VA	2000 VA
Adjusted peak current	16 A	30 A
Short-circuit current shut-	50 A	
Efficiency	97 %	
Power loss at rated nutrunner torque output	3 W	5 W
Clock speed of PWM	10 kHz	
Maximum temporary	4000 VA	

Power Loss

- Low power loss components limit heat radiation.
- The high admissible operating temperature of 50 °C reduces the need for additional cooling measures in many cases.
- The position of the brake resistors ensures that no other components of the TMH are influenced by the heat dissipated by them.

	TMH	
Nutrunner spindle type	17E…	47E/67E…
Total power loss at rated output of	27 W	29 W

Calculation of Temperature to be Expected inside Control Cabinet

To ensure safe operation and reach the service life of 20,000 hours, the TMH must be operated
in a control cabinet with a maximum inside temperature of 50 °C.

The temperature to be expected inside the control cabinet must be calculated when the

Formula:

$$Ti = Tu + \frac{Pv_{TM\ tot} + Pv_{additional\ heat\ sources}}{A \times k}$$

cabinet
is designed..

Ti	= Temperature to be expected inside control cabinet (in °C)
Tu	= Ambient temperature (room temperature in °C)
$Pv_{TM\ tot}$	= Overall power loss of all TMs (in W) From the intermediate circuit of the logic section
$Pv_{additional\ heat\ sources}$	= Power loss of all additional heat sources installed inside the control cabinet (in W)
A	= Effective cabinet surface (in m2) All free cabinet surfaces
k	= Heat transition coefficient of sheet metal = 5.0 (W/m^2K)

CAUTION!

At a calculated inside temperature (Ti) above 50° C additional cooling measures, such as an air conditioner or heat exchanger, are required.

Measuring Board

- The measuring board is part of the TMH and must not be replaced individually.
- It has separate processors for measuring and communication tasks, angle tracing and ARCNET.
- Separate 5 V supply.
- The measuring software is saved in a FLASH EPROM, reload is carried out via ARCNET from the station controller.
- Reset via servo amplifier or station controller (warm start).
- Two separate measuring channels for torque.
- Polling rate 5000 measurements per second.
- Resolution 12 bit at ±10 V.
- Analog filter for torque measuring signals 1 kHz.
- Angle signals are generated from the resolver signals of the servo amplifier and are output to the measuring port via the dual port RAM. The angle inputs at XS6 are not polled.

• Two angle inputs are available on XS7 for cross-checking.
• Maximum angle frequency 9 kHz, corresponds to 1500 revolutions per minute at the output attachment of the handtool, at a resolution of 1 pulse per degree.
• Acquisition of motor angle signals transmitted by the servo amplifier via Dual-Port-RAM. These are generated from the resolver signals.
• Acquisition of the motor current transmitted by the servo amplifier (via DPR).

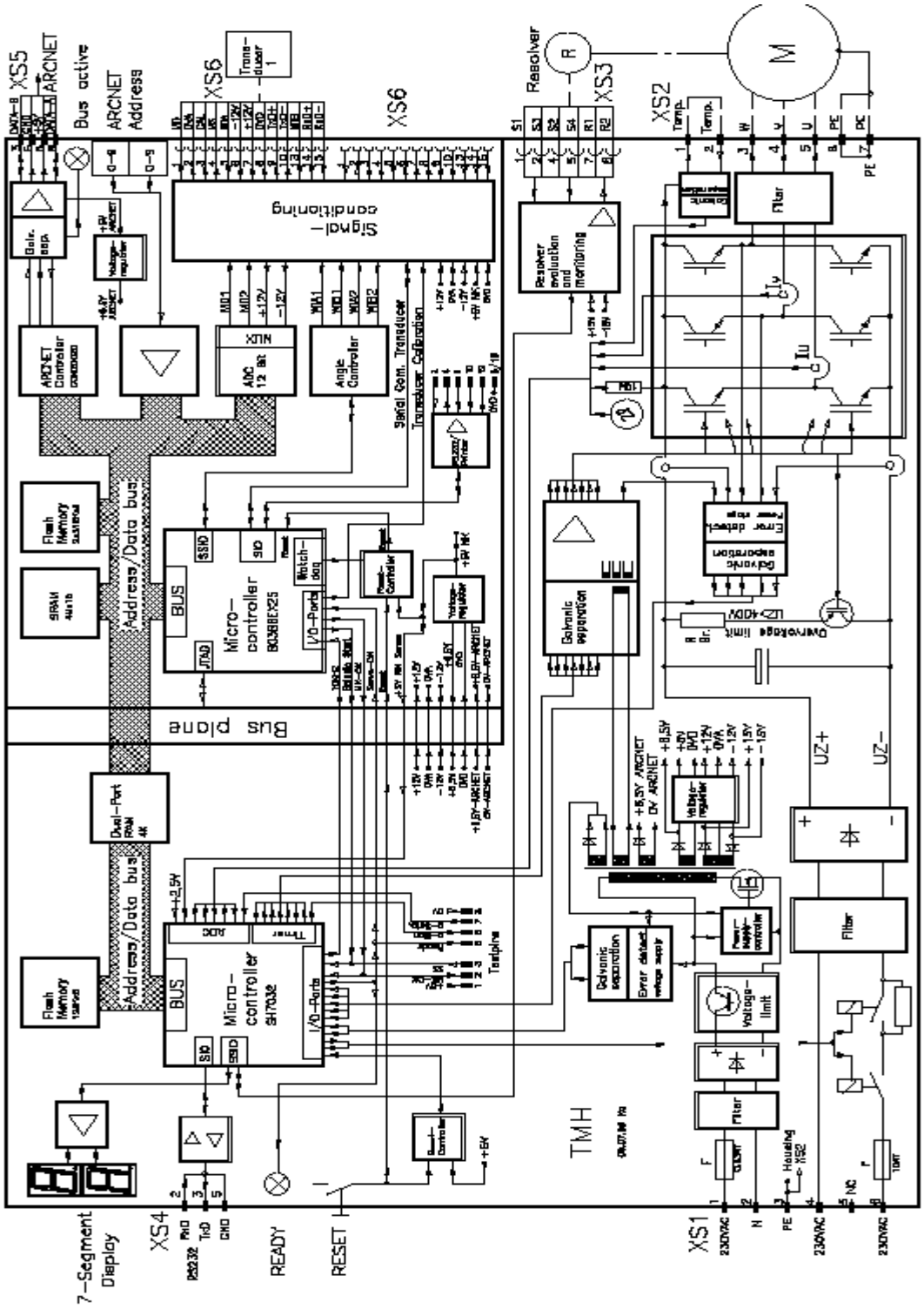
Communication between Measuring Board and Servo Amplifier Section

• A Dual-Port-RAM (DPR) is used for communication between servo amplifier and measuring board.
• For safety reasons, the start signal is transmitted via a direct line as well as via the Dual-Port-RAM from the measuring board to the servo amplifier section.

Communication between Measuring Board and Station Controller

• Communication is made via the high-performance FieldBus ARCNET.
• Transmission speed is 2.5 MBd.
• Maximum network distance 100 m.
• Star and tree topologies are possible with bus amplifier module HUB (Cooper Tools Ident No. 960920).
• Twisted and shielded two-wire cable (RS485).
• Bus termination at beginning and end of chain by bus termination adapter (Cooper Tools Ident. No. 960951) and bus termination (Cooper Tools Ident No. 960959).
• Use only Cooper Tools ARCNET cables with Ident No.: 960950-XXX (XXX=length in m).

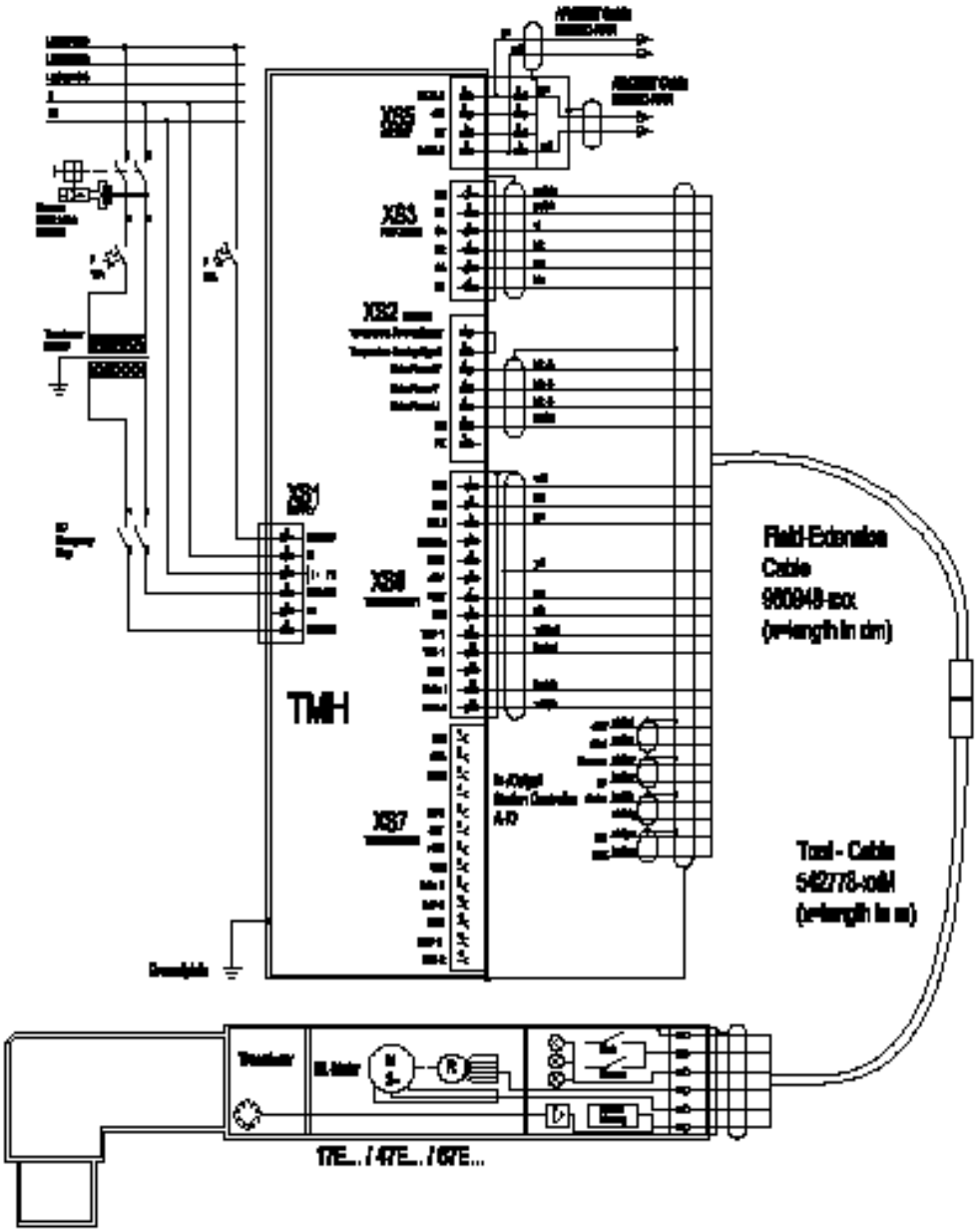
Block Diagram TMH

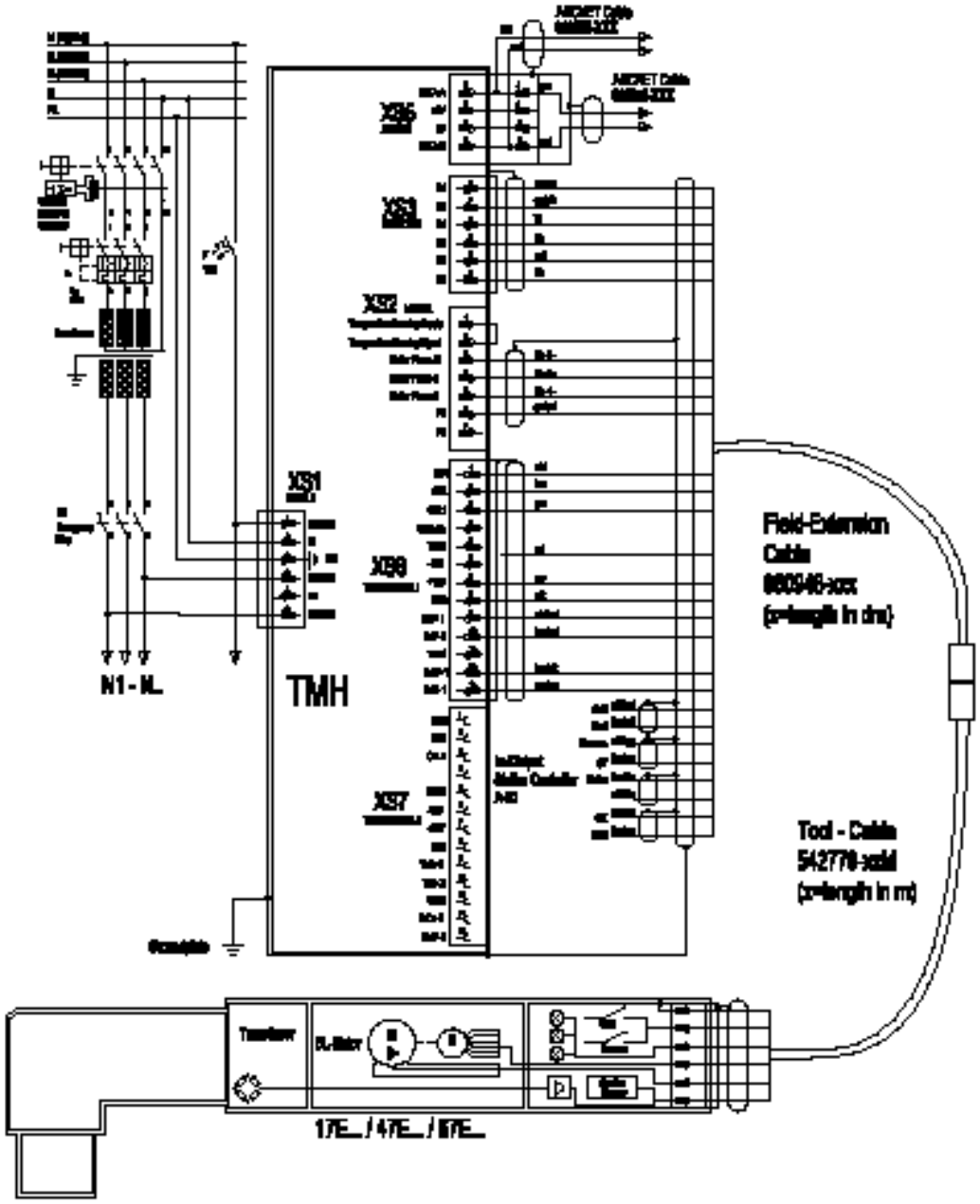


Explanation of Terms

ADC	analog - digital converter	Temp.	motor temperature
Address	address, channel number	Test pins	internal test connections
Angle Controller	processor for angle processing	Transducer and monitoringn	combined transducer for torque and angle and monitoring
ARCNET	network (field bus)	Transducer Calibration	calibration signal for combined transducer
Bus plane	bus circuit board	Voltage limit	voltage limit
Display	display	Voltage regulator	voltage regulator
Error detect	error detection		
voltage supply	voltage supply		
Filter	filter suppressing EMC interference		
Galvanic separation	galvanic separation		
Galv. sep.	galvanic separation		
Housing	housing		
MK	measuring board		
MUX	multiplexer		
Overvoltage limit	overvoltage limit		
Power Stage	output section		
Power supply controller	power supply controller		
Resolver	motor position tracing		
Resolver evaluation	resolver evaluation		
RS232/Printer	serial printer interface (internal)		
Serial Com. Transducer	serial data transmission to combined transducer		
Signal conditioning	signal conditioning		

Connecting Diagram TMH with Single-Phase Supply





Connecting Diagram TMH with Three-Phase Supply

Connections

• All plug in connections are located on the front of the TMH.
• To adapt the TMH connections to the tool cable an extension cable is required (Cooper Tools
No. 960948-XXX).
• All connections, except "XS1 Supply", can be secured from unintentional unplugging with
screws or slide locks.
• The connections for motor, resolver and transducer are compatible with the m-Pro-400 fastening
system with measuring board S Torque and servo amplifier BLSH.

CAUTION!

It is prohibited:

- **To operate the TMH and the handtool without PE (protected earth ground) connections! Fatal electric shock may occur.**
- **To use other connector types.**
- **To use cables other than those approved by Cooper Tools.**

Supply "Supply XS1"

• The connector coding ensures that the plug for XS1 cannot be plugged into XS2.

Type: PHOENIX Power-Combicon PC4/6-7,62
Cooper Tools Id. No.: 960942 (incl. coding on pin 1)

Pin	Description
1	Supply of intermediate circuit of logic section (logic power supply) (230 VAC)
2	Supply of intermediate circuit of logic section (logic power supply) N
3	PE
4	Supply intermediate circuit 230 VAC
5	nc
6	Supply intermediate circuit N 230 VAC

It is prohibited to remove the coding on the power connector plug or on the TMH.
If the plugs are confused, the TMH can be destroyed.

The TMH must be fastened to a zinc plated and earth grounded mounting plate.

High discharge current; connect earth ground before servicing.
Fatal electric shock may occur.

"Motor XS2"

• The connector coding on pin 1 and 2 ensures that the plug of XS1 cannot be plugged into
XS2.
• Cable breakage monitoring
• Integrated filtering of motor outputs.

Type: PHOENIX Power-Combicon PC4/7-7,62

Pin	Description
1	(motor temperature monitoring supply) not used in this application
2	(motor temperature monitoring signal) not used in this application
3	Motor phase W
4	Motor phase V
5	Motor phase U
6	PE (protected earth ground)
7	PE (protected earth ground)

The motor phases and the lines of the thermal switch must not be touched, even if the TMH is in failure mode.
Fatal electric shock may occur.

"Resolver XS3"

• All resolver signals are short-circuit protected, also to PE (protected earth ground).
• Cable breakage monitoring 9 pole D-Sub socket with lock screws, 4-40 UNC threads.

Type: 9 pole D-Sub socket with lock screws, 4-40 UNC threads.

Pin	Description	Input/Output	Signal Level
1	S1 cosine signal	Input	
2	S3 cosine signal	Input	0 V
3,6	Nc		
4	S2 sine signal	Input	
5	S4 sine signal	Input	0 V
7	R1 carrier signal	Output	11 Vpp, 10 kHz
8	R2 carrier signal	Output	0 V
9	Connected to PE (protected earth ground)		
Housing	Shield connected PE (protected earth ground)		

⚠ **It is prohibited to short circuit the lines or connections of the resolver, the interface RS232, the ARCNET, and the transducers to the supply, motor line, or the temperature contact of the motor.**
The TMH will be destroyed.

Service Interface "RS232 XS4"

• Service PC interface via null modem cable (Cooper Tools Id. No.: 960007).
• Short-circuit protected

Type: 9 pole D-Sub pins with lock screws, 4-40 UNC threads.

Pin	Description
2	RxD
3	TxD
5	GND
1, 4, 6, 7, 8, 9	Nc
Housing	Shield connection PE (protected earth ground)

"ARCNET XS5"

- Short-circuit protected
- Galvanic separation from all other functional assemblies of the TMH.

Type: 9 pole D-Sub pins with slide lock systems

Pin	Description
1	PE
2, 4, 7, 9	nc
3	DATA-B
5	GND (ARCNET)
6	+5 V (ARCNET)
8	DATA-A
Housing	Shield connection PE (protected earth ground)

Transducer No. 1 "XS6" Controlling Transducer Integrated in the Handtool

- Short-circuit protected

Pin	Description	Output	Signal Level
1	Measuring signal	Analog input	-5…+5 V, (measuring range –6.25…+6.25 V)
2	Supply analog 0 V	Output	0 VA
3	Calibration signal	Output	+5 V (±0.5 V), I_{max} = 15 mA
4	Cross-checking adaptor on	Output	+5 V (±0.5 V), Ri = 500Ω
5	Angle track 1	Input	0…5 V = 0.7…12 V = 1, pull-up 1 kΩ
6	Supply –12 V	Output	-12 V (±0.2 V), I_{max} = 100 mA

7	Supply +12 V	Output	+12 V (±0.2 V), I_{max} = 200 mA
8	Supply digital 0 V	Output	0 VD
9	Interface RS422 TxD+*	Output	5 V, Ri = 500 Ω
10	Interface RS422 TxD-*	Output	0 V, Ri = 500 Ω
11	Nc		
12	Nc		
13	Angle track 2	Input	0…5 V=0.7…12 V = 1, pull-up 1 kΩ
14	Interface RS422 RxD+*	Input	
15	Interface RS422 RxD-*	Input	
Housing	Shield connection PE (protected earth ground)		

* Not used in this application

Transducer No. 2 "XS7" Redundant Transducer

- Short-circuit protected

Type: 15 pole HD-Sub socket with lock screws, 4-40 UNC threads

Pin	Description	Input/Output	Signal level/Data
1	Measuring signal	Analog input	-5…+5 V, (measuring range –6.25…+6.25 V)
2	Supply analog 0 V	Output	0 VA
3	Calibration signal	Output	+5 V (±0.5 V), I_{max} = 15 mA
4	(Cross-checking adapter on)*	Output	+5 V (±0.5 V), Ri = 500Ω
5	Angle track 1	Input	0…5 V = 0.7…12 V = 1, pull-up 1 kΩ
6	Supply –12 V	Output	-12 V (±0.2 V), I_{max} = 100 mA
7	Supply +12 V	Output	+12 V (±0.2 V), I_{max} = 200 mA
8	Supply digital 0 V	Output	0 VD
9	Interface RS422 TxD+	Output	5 V, Ri = 500 Ω

10	Interface RS422 TxD-	Output	0 V, Ri = 500 Ω
11	Nc		
12	Nc		
13	Angle track 2	Input	0…5 V=0.7…12 V = 1, pull-up 1 kΩ
14	Interface RS422 RxD+	Input	
15	Interface RS422 RxD-	input	
Housing	Shield connection PE		

* Not used in this application

Operating Elements

"RESET" Button

- Processor reset for all internal functions of the TMH.
- Used to acknowledge failures.
- Pressing results in reconfiguration of all functions.

Selector Switch for ARCNET "Address"

- Adjusts ARCNET address.
- BCD-code switch, upper switch for tens digit (**0**0-**9**0), bottom switch for ones digit (0**0**-0**9**).
- Admissible settings 01 to 32.
- Adjust only when supply is switched off.
- If two or more modules have the same address, the error code 50 is output.
- The address adjustment can be checked upon power-up or reset at the two-digit 7-segment display.

Displays

Status and Diagnosis Display

- Red 7-segments two-digit.
- Operating conditions and error codes (flashing) are displayed.

Operating conditions

Upon power-up or reset the following messages are displayed:

- Lamp test, that is, all 2 x 7 segments are on (**88**) for 1 second.
  Then the display is off for approx. 0.5 seconds.
- The adjusted ARCNET address, is displayed as **01 - 32** for 1 second.
  Then the display is off for approx. 0.5 seconds.
- Selected handtool control parameter set will be shown on the bottom display; "**2**" will appear
  for 17E... or "**4**" will appear for 47E.. or 6 for 67E... for 1 second; while the upper display will
  not be on.

During fastening operation:

- Display during fastening **11 - FF**
  The top display shows the selected fastening program.
  The bottom display shows the selected fastening stage.
- Overload, display **IP**
  If current above the maximum admissible current is drawn during a fastening cycle, the
  servo amplifier shuts-off automatically and IP is displayed.
  The overload error is reset by a restart.

Im test operation controlled by station controller

- drive active, top display **A**, bottom display not on

LED"READY"

- Color green.
- Indicates ready to operate condition of the TMH.
- If all supply voltages are present and no failure is present, this LED is on

LED "Bus active"

- Color green.
- Displays ARCNET bus activity.
- If data is being transferred on the ARCNET bus, this LED is on.

Troubleshooting

To allow fast diagnosis of errors, LEDs and a two-digit 7-segment display are installed on the
front panel.

Display of Errors

- The errors are shown as codes. The display **00 - 99 flashes** at a frequency of approx. 1 Hz.
- If an error occurs in the TMH, in the main power supply, in the motor, in the transducers or in the ARCNET, the error codes listed in the table below are immediately triggered.
- If several errors occur at the same time, the failure with the highest priority, that is the lowest number, is displayed.
  Exceptions:
  - Error **64** "Torque- +12 V NOK"
    has priority over **15, 16, 17, 21, 22, 28, 40** and **41** (description see table).
  - Error **65** "Torque- -12 V NOK"
    has priority over **15, 16, 17, 28** and **40** (description see table).
  - The failure **40** "Torque is not ready" has the lowest priority, since the errors **41** to **FF** cannot be described as a common error (**40**) to simplify error diagnosis.
- All errors are reported to the station controller via the ARCNET and are then displayed on its monitor.

In the rundown data table the abbreviations "**FLT, F Torque, AN1F, AN2F, OFF1, OFF2,...**" are
shown in the "ERROR" column.
In the rundown data table the window "Spindle monitor" opens.
When the soft key "i" is pressed the error list is opened and all current errors are displayed as
descriptive text.

Acknowledging errors

• When the error has been resolved, press the RESET button to return the TMH to the ready condition.

• Upon each nutsetter start, the measuring board sends an acknowledgement signal to the output section.

If the error is momentary only (e. g. undervoltage), the TMH automatically returns to the ready state after the next acknowledgement signal.

Since all errors are archived by the station controller, the error information can be displayed for troubleshooting. However, the display of the TMH does not flash anymore once an error has been acknowledged.

• If an error is permanent, the error mode cannot be acknowledged and quit.

When measuring continuity, impedance or checking for a short-circuit in the motor or motor cable, be sure to disconnect these from the TMH.
Fatal electric shock may occur.

DISPLAY 88	Top Display Bottom Display Error Explanation	Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
00	**Supply DC/DC converter undervoltage** Supply DC/DC converter undervoltage < 150 VAC	X	X	X		• Measure supply voltage If < 200 VAC increase to 230 VAC • If errors occur sporadically, check the supply for voltage drops • Internal error, replace TMH
01	**Supply DC/DC converter overvoltage** The voltage of the intermediate circuit of logic section is > 440 VDC	X		X		• Measure supply voltage If > 255 VAC decrease to 230 VAC • If error occur sporadically, check the supply for voltage overshoot • Internal error, replace TMH
02	**Intermediate circuit of the power Section Not supplied**	X	X		X	• Check supply (prefusing of TMH, EMERGENCY STOP contactor, etc.) • Internal error, replace TMH
11	**Motor cable defective** • Cable in motor lines broken • Interruption in the connector board • Motor phases interrupted • Test current of cable monitoring misguided	X	X	X		• Check tool cable and connector board for continuity and short-circuit • Check motor for short-circuit to PE and check phase impedance (17E…approx. 7 Ω 47E…approx. 4 Ω

						67 E… approx. 2Ω) • Replace handtool • Internal error, replace TMH
12	**Short-circuit in motor circuit** • In cable • In motor • In TMH	X	X	X		• Check tool cable for short-circuit • Check motor for short-circuit (phase impedances see failure 11) • Internal error, replace TMH

DISPLAY **88**	**Top Display** **Bottom Display** **Error Explanation**	**Consequence**				**Measures, Remedy**
		LED-Ready off	**Main and Startup Relay**	**Output Section Off**	**Brake Motor, Output Section Off**	
13	**(Motor temperature too high)*** • Measuring line broken • Measuring current misguided • Motor not connected * Not used in this application	X	X	X		• Check XS2 Pin 1 –2 for connections • Internal error, replace TMH
14	**I^2T monitoring** • Required motor output is too high • Handtool is defective (e.g. gearing, bearing)	X		X		• Check handtool temperature, if > 60 °C, decrease fastening time by increasing the speed • Replace handtool • Internal error, replace TMH

15	**Resolver error** The resolver signals are • Interrupted • Shorted • Not present The internal +/- 12 V power supply is • shorted	X		X		• Handtool connected? • Check tool cable for continuity and short-circuit, especially the +/- 12 V and 0 V conductors • Replace handtool • Internal defect, replace TMH
16	**Intermediate circuit voltage too high** The voltage of the intermediate circuit of the power section is > 400 VDC	X	X	X		Permanent error: • Measure supply voltage If > 255 VAC, reduce to 230 VAC During braking: • Capacitors in intermediate circuit are open • Brake chopper is defective, replace TMH Sporadically: • The supply voltage is too high sporadically; connect next higher tap of transformer (if 3-phase isolation transformer is available) • Internal error, replace TMH

DISPLAY **88**		**Consequence**				**Measures, Remedy**
	Top Display **Bottom Display** **Error Explanation**	**LED-Ready off**	**Main and Startup Relay**	**Output Section Off**	**Brake Motor, Output Section Off**	

17	**Intermediate circuit voltage too low** The voltage of the intermediate circuit is < 150 VDC	X	X		X	Permanent error: • Measure supply voltage if < 200 VAC increase to 230 VAC During fastening: • The supply is too “weak” or overloaded, ensure more stable supply (e.g. larger isolation transformer) • Capacitors in intermediate circuit are open, replace TMH • Internal error, replace TMH
20	**Temperature in output section too high** The temperature in TMH is > 80°C	X	X	X		• Measure temperature inside cabinet below TMH, if ϑ > 50°C, additional cooling (e.g. air conditioner) required. • Cooling slots of TMH must not be covered by cables or similar. • Internal error, replace TMH
21	**Start-up relay does not open** Due to an internal error, the contact in the start-up relay sticks.	X	X	X		• Internal error, replace TMH
22	**Main relay does not open** Due to an internal error, the contact in the main relay sticks.	X	X	X		• Internal error, replace TMH

DISPLAY 88 Top Display Bottom Display Error Explanation	n 2 Consequence				Measures, Remedy
	LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
25 **5 V supply in servo too low** The 5 V power supply for internal supply of the servo amplifier is overloaded. U < 4.8 VDC	X	X	X		• Internal error, replace TMH
26 **5 V supply in servo too high** The 5 V power supply for internal supply of the servo amplifier is defective. U > 5.2 VDC	X	X	X		• Internal error, replace TMH
27 **Driver supply of output section too low** The power supply for internal supply of the output section is overloaded or defective	X	X	X		• Internal error, replace TMH
28 **Offset of current measurement too high** The zero-point of the integrated motor current measurement has been shifted.	X	X	X		• Internal error, replace TMH
30 **5 V supply in measuring board too low** The power supply for internal supply of the measuring board is overloaded or defective. U < 4.8 VDC	X			X	• Internal error, replace TMH

DISPLAY 88	Top Display Bottom Display Error Explanation	n 3 Consequence				Measures, Remedy
		LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	
31	**5 V supply in measuring board too high** The 5 V power supply for internal supply of the measuring board is defective. U > 5.2 VDC	X			X	• Internal error, replace TMH
32	**DPR error servo** The Dual-Port-Ram for communication between servo and measuring board is defective.	X			X	• Internal error, replace TMH
33	**Flash error servo** The flash memory is defective	X	X	X		• Internal error, replace TMH
34	**DPR communication to Torque interrupted** The Dual-Port-RAM communication between servo and measuring board is failing.	X			X	• Internal error, replace TMH

35	**Start signal sequence faulty** Communication error between measuring board and servo amplifier	X			X	• Internal error, replace TMH • Inform Cooper Tools service department
38	**MOTID error** Error in motor identification mode	X		X		• Internal error, replace TMH
39	**Mathematic error, illegal command etc.** Error in program processing	X		X		• Internal error, replace TMH • Inform Cooper Tools service department
40	**Measuring board not ready** The signal “measuring board OK” is not received by the servo section	X			X	• Measuring board present? • Measuring board firmly secured to TMH? • Internal error, replace TMH

DISPLAY 88	Top Display Bottom Display Error Explanation	n 4 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
50	**ARCNET multiple address** The address adjusted on this TMH already exists.					• Check addressing, that is switch settings of ARCNET, each client must have a unique address. • Internal error, replace TMH
51	**ARCNET address faulty** The selected address is not in the permissible range.					• Change address to be in the range between 01 and 32 • Internal error, replace TMH
52	**ARCNET Error** Communication error					Check ARCNET: • Bus terminators installed? • Are the clients with the bus terminations switched on? • All cables plugged in? • Check addressing of ARCNET, that is, switch settings. • Internal error, replace TMH • Inform Cooper Tools service department
53	**ARCNET Recon** Too many reconfigurations, network is unstable					Check ARCNET: • Bus terminators installed? • All ARCNET cables plugged in? • Check addressing of ARCNET, that is, switch settings. • Are the clients with the bus

						terminations switched on?
54	**ARCNET – not connected to network** The TMH is not connected to the ARCNET.				X	Check ARCNET • Bus terminators installed? • Are the clients with the bus terminations switched on? • All cables plugged in • Internal error, replace TMH

DISPLAY 88 Top Display Bottom Display Error Explanation	n 5 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
61 **Torque measuring card parameters are wrong** Fastening parameters in measuring board are NOK					Check programming of station controller: • Handtool constants • Calibration values • Fastening strategy (SEQ) • Fastening stage • Parameter set
62 **Torque – Memory overflow** Not enough RAM storage available					• Inform Cooper Tools service department • Internal error, replace TMH
64 **Torque - + 12 V NOK** The +12 V supply of the measuring board is out of tolerance limits between +11.8 V… -12.2 V	X		X		Check at station controller in test mode, the value out of tolerances: • Check tool cable, especially the +12 V and 0 V and the resolver conductors • Replace handtool • Internal error, replace TMH
65 **Torque - - 12 V** The –12 V supply of the measuring board is out of tolerance limits between -11.8 V… -12.2 V	X		X		Check at station controller in test mode, the value out of tolerances: • Check tool cable, especially the -12 V and 0 V conductors • Check resolver cable for short-circuit • Replace transducer • Replace motor

						• Internal error, replace TMH
66	**Torque – Process control** Process sequence - start stage - graphics not adhered to					• Inform Cooper Tools service department • Internal error, replace TMH

DISPLAY 88	Top Display Bottom Display Error Explanation	n 6 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
68	**Torque – Initialization NOK** Initialization error in measuring board					• Inform Cooper Tools service department • Internal error, replace TMH
69	**Torque – access to DPR NOK** The measuring board cannot access the DPR in the servo					• Measuring board firmly screwed inside TMH • Internal error, replace TMH
6A	**Torque – servotype not TMH** The TMH type read by the measuring board is unknown			X		• Internal error, replace TMH
6C	**Torque – no cycle signal from servo** The synchronization signal between servo and measuring board is not present			X		• Measuring board firmly secured to the TMH? • Internal error, replace TMH
6E	**Torque – servo parameters do not fit servo** The parameter set selected by the measuring board is not available in the TMH			X		• Check programming of system • Internal error, replace TMH
71	**Transducer 1 not present** The transducer signal is • interrupted • shorted • not present					• Handtool connected? • Check tool cable for continuity and short-circuit • Replace handtool • Internal error, replace TMH

72	**Transducer 1 Offset NOK** The zero-point voltage is out of the admissible range between –200 mV… +200 mV					• Torque transducer defective or installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace handtool • Internal error, replace TMH

DISPLAY 88	Top Display Bottom Display Error Explanation	n 7 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
73	**Transducer 1 calibration voltage NOK** The calibration voltage is out of the admissible range between +4.85 V… +5.15 V					• Torque transducer defective or installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace handtool or transducer • If deviation is extreme, check tool cable, especially the calibration line • - Internal error, replace TMH
81	**Transducer 2 not present** The transducer signal is • interrupted • shorted • not present					• Is the tool connected? • Check tool cable for continuity and short-circuit • Replace transducer • Internal error, replace TMH
82	**Transducer 2 Offset NOK** The zero-point voltage is out of the admissible range between -200 mV… +200 mV					• Transducer installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace transducer • Internal error, replace TMH

83	**Transducer 2 calibration voltage NOK** The calibration voltage is out of the admissible range between +4.85 V…+5.15 V					• Transducer installed in jammed position • Check with test mode of station controller if values are out of admissible ranges, if so, replace transducer or handtool • If deviation is extreme check tool cable, especially the calibration line • Internal error, replace TMH

DISPLAY 88	Top Display Bottom Display Error Explanation	n 8 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
84	**Transducer 2 angle tracing NOK** The angle signals are • Interrupted • Shorted • Not present • Not present part of the time					Check at the station controller If no angle signals are detected in test mode: • Check tool cable especially the angle signal lines Handtool rotates more than 360 degrees: • Check angle factor • Replace transducer or handtool • Internal error, replace TMH
90	**Torque – exception** Error in program processing					• Internal error, replace TMH • Inform Cooper Tools service department
92	**Torque – General initialization error** Initialization of internal communication interfaces is NOK					• Internal error, replace TMH • Inform Cooper Tools service department
93	**Torque – communication error** Communication interfaces are NOK					• Internal error, replace TMH • Inform Cooper Tools service department

96	**Servo not OK** Ready signal from servo is not present					• Measuring board firmly secured to TMH? • Internal error, replace TMH
98	**Flash error** Program update not possible The station controller is trying to send a faulty program					• Check program selection • Internal error, replace TMH • Inform Cooper Tools service department
99	**Task ID error** Software monitoring					• Internal error, replace TMH • Inform Cooper Tools service department

DISPLAY 88	Top Display Bottom Display Error Explanation	n 9 Consequence LED-Ready off	Main and Startup Relay	Output Section Off	Brake Motor, Output Section Off	Measures, Remedy
IP	**Overload (not flashing)** If a current above the admissible maximum current is drawn during fastening, the servo amplifier shuts-off automatically. • Error in motor position tracing, e.g. resolver, cable • Error in motor circuit e.g. motor does not reach required torque					Check system programming: • Handtool selection • Required torque Check motor position tracing • Check tool cable and replace if necessary • Replace handtool • Internal error, replace TMH • Check tool cable • Replace handtool

LED's "READY" and "Bus active"

Error	Measures, Remedy
LED "READY" not on The TMH is not ready 7-segment display flashes	• Check supply voltages • Internal error, replace TMH Refer to Display of Errors

LED "Bus active" flashes at approx. 1 Hz frequency ARCNET – communication interrupted	Check ARCNET connection: • Check all connector locks • Check ARCNET cable for continuity and short-circuit
LED "Bus active" not on	• Internal error, replace TMH
Status and diagnosis display flashes	• Refer to Display of Errors

SECTION 17
Tool Library Settings

Cleco Handtools

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
17 Series Right Angle Tools						
17EA08AL2	2000	8	8.5	28.373	32	9.975
17EA15AM3	860	15	16.6	65.640	32	23.0776
17EA22AM3	610	22	23.0	92.640	32	32.5696
17EA28AM3	465	28	41.4	121.257	32	42.63
17 Series Inline Tools						
17ES06ZA	2600	6	7.0	21.333	32	7.5
17ES12ZA	1200	12	12.9	46.886	32	16.484
17ES17ZA	860	17	17.9	66.172	32	23.264
17ES06Q	2600	6	7.0	21.333	32	7.5
17ES12Q	1200	12	12.9	46.886	32	16.484
17ES17Q	860	17	17.9	66.172	32	23.264
17ES06D2	2600	6	7.0	21.333	32	7.5
17ES12D3	1200	12	12.9	46.886	32	16.484
17ES17D3	860	17	17.9	66.172	32	23.264
17ES22D3	650	22	32.2	86.612	32	30.45

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
17 Series Pistol Tools						
17EP06Q	2600	6	7.0	21.333	32	7.5
17EP12Q	1200	12	12.9	46.886	32	16.484
17EP17Q	860	17	17.9	66.172	32	23.264
17EP06D2	2600	6	7.0		32	7.5
17EP12D3	1200	12	12.9	46.886	32	16.484
17EP17D3	860	17	17.9	66.172	32	23.264
17EP22D3	650	22	32.2	86.612	32	30.45
47 Series Right Angle Tools						
47EA33AM3	895	33	66.9	63.504	34	22.32613
47EA43AM3	685	43	65.5	82.831	34	29.12082
47EA60AM3	485	61	64.2	116.555	34	40.97653
47EA60AM4	485	61	64.2	116.555	34	40.97653
47EA90AH4	340	87	158.4	165.687	34	58.24998
47EA105AH4	230	104	156.7	248.086	34	87.21911
47EA135MH4	180	133	199.7	316.246	34	111.1821
47EA175AX5	130	176	231.2	441.626	34	155.261
47EA230AX5	100	230	228.7	576.034	34	202.5155

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
47 Series Inline Tools						
47ES12ZA	2600	12	19.8	21.333	34	7.5
47ES221ZA	1490	22	43.6	38.095	34	13.393
47ES281ZA	1145	28	42.7	49.689	34	17.469
47ES401ZA	810	40	41.9	69.919	34	24.581
47ES602ZA	570	57	103.3	99.392	34	34.943
47ES702ZA	380	68	102.2	148.822	34	52.321
47ES802ZA	300	82	153.7	188.271	34	66.19
47ES1152ZA	215	115	150.8	264.923	34	93.138
47ES1502ZA	165	150	149.1	345.551	34	121.485
47ES1653ZA	150	165	375.8	380.672	34	133.8317
47ES2503ZA	100	247	371.7	569.987	34	200.3894
47ES12Q	2600	12	14.0	21.333	34	7.5
47ES12D2	2600	12	14.0	21.333	34	7.5
47ES25D3	1200	25	33.2	46.886	34	16.484
47ES36D3	860	36	37.8	66.172	34	23.264
47ES48D3	650	48	49.8	86.612	34	30.45
47 Series Pistol Tools						
47EP12Q	2600	12	14.0	21.333	34	7.5
47EP12D2	2600	12	14.0	21.333	34	7.5
47EP25D3	1200	25	33.2	46.886	34	16.484

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
47EP36D3	860	36	37.8	66.172	34	23.264
47EP48D3	650	48	49.8	86.612	34	30.45
47 Series TubeNut Tools						
47ET20T2ED00	950	20	36.0	59.732	34	21
47ET20T2MD00	950	20	36.0	59.732	34	21
47ET20T2MG00	950	20	36.0	59.732	34	21
47ET30T3EF00	680	30	49.9	82.772	34	29.1
47ET30T3MG00	680	30	49.9	82.772	34	29.1
47ET30T3MM00	680	30	49.9	82.772	34	29.1
47ET40T4EK00	515	40	66.2	109.865	34	38.625
47ET40T4EM00	515	40	66.2	109.865	34	38.625
47ET40T4MR00	515	40	66.2	109.865	34	38.625
47ET40T4MU00	515	40	66.2	109.865	34	38.625
67 Series Right Angle Tools						
67EA235AL6	145	230	278.7	247.942	36	87.16867
67EA255AL6	125	255	277.7	292.562	36	102.8554
67EA340AM6	100	335	462.3	366.696	36	128.9188
67EA460AM6	73	460	462.3	503.614	36	177.0538
67EA570AM6	60	570	707.1	622.015	36	218.6806

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
67EA730AM6	46	730	707.1	795.705	36	279.7455
67EA860AH8	36	860	1768.2	1014.299	36	22.2872
67EA1035AH8	28	1035	1768.2	1305.194	36	28.67977
67EA1340AH8	22	1340	1768.2	1665.956	36	36.60673
67EA1700AH8	17	1700	1768.2	2125.475	36	46.7024
67EA2010AH8	15	2000	3612.0	2508.004	36	55.10939

DGD Tools

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor pulses/deg	Servo Parameter Set	Gear Ratio	Static Torque Factor	Encoder Angle Factor pulses/deg
	Max Speed (RPM)	Max Torque (Nm)						
Size 1 DGD Tools								
1B030A-1K1A-1ZA	462	30	35	43.05450	1B	15,1364	4.46400	1.000
1B030A-1K1A-1VA	439	30	35	45.32060	1B	15,9330	4.55900	1.053
1B030A-1VK1A	439	30	35	45.32060	1B	15,9330	4.55900	1.000
1B030A-1K1A-1WA	433	30	35	45.92480	1B	16,1455	4.43000	1.067

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor pulses/deg	Servo Parameter Set	Gear Ratio	Static Torque Factor	Encoder Angle Factor pulses/deg
	Max Speed (RPM)	Max Torque (Nm)						
1B050A-1K2A-1ZA	271	50	60	73.30910	1B	25,7727	7.59900	1.000
1B050A-1VK2A	258	50	60	73.30910	1B	27,1292	7.76200	1.000
1B050A-1K2A-1VA	258	50	60	77.16750	1B	27,1292	7.76200	1.053
1B050A-1K2A-1WA	254	50	60	78.19640	1B	27,4909	7.54100	1.067
Size 2 DGD Tools								
2B100A-2K1A-2ZA	329	100	110	43.24590	2B	15,2036	5.86400	1.000
2B100A-2VK1A	307	100	110	43.24590	2B	16,2896	6.07400	1.000
2B100A-2K1A-2VA	307	100	110	46.33480	2B	16,2896	6.07400	1.071
2B100A-2K1A-2WA	309	100	110	45.94870	2B	16,1538	5.78000	1.063
2B150A-2K2A-2ZA	219	150	170	64.94090	2B	22,8307	8.62600	1.000
2B150A-2VK2A	204	150	170	65.57.95	2B	24,4615	8.96200	1.000
2B150A-2K2A-2VA	204	150	170	65.57.95	2B	24,4615	8.96200	1.071
2B150A-2K2A-2WA	206	150	170	68.99970	2B	24,2577	8.52800	1.063

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor pulses/deg	Servo Parameter Set	Gear Ratio	Static Torque Factor	Encoder Angle Factor pulses/deg
	Max Speed (RPM)	Max Torque (Nm)						
Size 3 DGD Tools								
3B180A-3K1A-3ZA	339	180	200	41.91810	3B	14,7368	5.87800	1.000
3B180-3VK1A	315	180	200	45.14260	3B	15,8704	5.82400	1.000
3B180A-3K1A-3VA	315	180	200	45.14260	3B	15,8704	5.82400	1.077
3B180A-3K1A-3WA	327	180	200	43.53060	3B	15,3036	5.61400	1.038
3B260A-3K2A-3ZA	220	260	300	64.76580	3B	22,7692	9.11700	1.000
3B260A-3VK2A	204	260	300	69.74780	3B	24,5207	9.03400	1.000
3B260A-3K2A-3VA	204	260	300	69.74780	3B	24,5207	9.03400	1.077
3B260A-3K2A-3WA	211	260	300	67.25680	3B	23,6450	8.70700	1.038
Size 4 DGD Tools								
4B360A-4K1A-4ZA	266	360	400	74.84240	4B	26,3118	6.56200	1.000
4B360-4VK1A	249	360	400	79.83180	4B	28,0659	6.58000	1.000
4B360A-4K1A-4VA	249	360	400	79.83180	4B	28,0659	6.58000	1.067
4B360A-4K1A-4WA	256	360	400	77.61430	4B	27,2863	6.39500	1.037

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor pulses/deg	Servo Parameter Set	Gear Ratio	Static Torque Factor	Encoder Angle Factor pulses/deg
	Max Speed (RPM)	Max Torque (Nm)						
4B460A-4K1A-4ZA	209	460	660	95.06670	4B	33,4219	8.51400	1.000
4B460-4VK2A	196	460	660	101.40440	4B	35,6500	8.35800	1.000
4B460A-4K1A-4VA	196	460	660	101.40440	4B	35,6500	8.35800	1.067
4B460A-4K1A-4WA	201	460	660	98.58770	4B	34,6597	8.12300	1.037
4B530-4VK2A	134	530	660	150.23840	4B	52,8182	12.23800	1.000
4B630A-4K2A-4ZA	143	630	660	140.84850	4B	49,5170	12.46700	1.000
4B630A-4K2A-4VA	134	630	660	150.23840	4B	52,8182	12.23800	1.067
4B630A-4K2A-4WA	137	630	660	146.06510	4B	51,3510	11.89400	1.037

NM X 0.73756 = Ft#, Nm X 8.8507 = In#

- Angle deviation:
  10 degrees if application requires torque control with angle monitoring (Sequence 30).
  5 degree if application requires angle or gradient control with torque monitoring (Sequence 50 or 63), unless otherwise specified.
- (Max. angle deviation can be as much as 8 degrees per revolution depending on spindle type).

Torque deviation:
Nominal value is 10% of transducer calibration factor, unless otherwise specified.

Current adjustment:
Nominal value is 1.0, until adjusted by reference to a calibrated transducer.

Rotor Tools

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
150 Series Angle Tools						
EMR150RAYSGG11	1060	15	17.1	39.167	35	9.4
EMR150RAYSGG13	760	17	16.7	54.756	35	13.141
EMR150RAYSGG17	610	23	35.5	68.014	35	16.323
EMR150RAYSGG22	490	29	35.1	84.375	35	20.25
EMR150RAHYSGG17	610	23	35.5	68.014	35	16.323
EMR150RAHYSGG22	490	29	35.1	84.375	35	20.25
EMR150RAHYSGG26	390	35	34.7	106.250	35	25.5
EMR150RAHYSGG32	310	43	50.6	133.797	35	32.111
EMR150RAHYSGG36	275	49	50.6	150.000	35	36.0
EMR150RAHYSGG39	220	52	50.1	188.889	35	45.333
EMR150RAHHYSGG3	270	50	49.6	141.797	35	25.5
EMR150RAHHYSGG4	210	63	72.3	191.150	35	32.111
EMR150RAHHYSGG5	190	71	72.0	214.300	35	36.0
EMR150RAHHYSGG6	150	88	103.9	269.858	35	45.333
EMR150RAHHYSGG7	130	105	103.5	317.086	35	53.267

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
225 Series Angle Tools						
EMR225RAYSGG30	830	41	71.3	43.333	37	10.4
EMR225RAYSGG39	645	53	70.7	55.750	37	13.38
EMR225RAYSGG44	580	60	145.9	61.908	37	10.4
EMR225RAYSGG56	450	76	143.1	79.647	37	13.38
EMR225RAYSGG72	355	98	140.9	101.672	37	17.08
EMR225RAYSGG81	315	110	140.1	113.578	37	19.08
EMR225RAYSGG92	275	125	139.1	129.711	37	21.79
EMR225RAYSGG109	235	148	282.5	153.106	37	25.72
EMR225RAHYSGG92	275	125	139.1	129.711	37	21.79
EMR225RAHYSGG10	235	148	282.5	153.106	37	25.72
EMR225RAHYSGG13	190	183	280.4	189.833	37	31.89
EMR225RAHYSGG15	170	205	280.0	211.919	37	35.6
EMR225RAHYSGG17	145	233	278.7	242.158	37	40.68
EMR225RAYG195	125	264	365.0	282.694	37	61.05
EMR225RAYG230	105	312	365.0	331.364	37	71.56
EMR225RAYG250	100	339	462.3	357.992	37	61.05
EMR225RAYG290	88	393	462.3	419.619	37	71.56
EMR225RAYG340	73	461	462.1	491.864	37	83.88
EMR225RAYG420	60	570	707.0	607.439	37	103.587
EMR225RAYG540	46	731	707.0	777.083	37	132.52
EMR225RAYGG44MR	36	861	1767.0	990.542	37	10.4
EMR225RAYGG56MR	28	1037	1767.0	1274.753	37	13.38
EMR225RAYGG72MR	22	1342	1767.0	1627.156	37	17.08
EMR225RAYGG81MR	20	1485	1767.0	1816.978	37	19.08
EMR225RAYGG92MR	17	1702	1767.0	2075.758	37	21.79
EMR225RAYGG109M	15	2007	3611.2	2448.592	37	25.72

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
150 Series Inline Tools						
EMR150RYSGG8	1140	10	11.7	36.503	35	13.141
EMR150RYSGG10	920	13	25.0	45.342	35	16.323
EMR150RYSGG13	740	17	24.7	56.250	35	20.25
EMR150RYSGG17	585	23	24.4	70.833	35	25.5
EMR150RYSGG21	465	28	35.5	89.197	35	32.111
EMR150RYSGG24	415	32	35.4	100.000	35	36.0
EMR150RYSGG30	330	40	51.0	125.925	35	45.333
EMR150RYSGG35	280	47	50.9	147.964	35	53.267
225 Series Inline Tools						
EMR225RYSGG29	970	39	70.2	37.178	37	13.384
EMR225RYSGG37	760	50	69.2	47.456	37	17.084
EMR225RYSGG47	595	64	65.4	60.539	37	21.794
EMR225RYSGG55	505	75	138.7	71.442	37	25.719
EMR225RYSGG62	450	84	138.2	79.772	37	28.718
EMR225RYSGG69	405	94	137.8	88.572	37	31.886
EMR225RYSGG77	365	104	137.4	98.889	37	35.6
EMR225RYSGG88	320	119	136.8	112.986	37	40.675
EMR225RYSGG104	270	141	136.4	133.333	37	48.0
EMR225RYSGG118	235	160	176.7	152.333	37	54.84
EMR225RYSG125	213	170	298.3	169.575	37	61.047
EMR225RYSG140	180	190	298.3	198.767	37	71.556
EMR225RYSG170	155	230	298.3	232.989	37	83.876
EMR225RYSG210	125	285	298.3	287.742	37	103.587
EMR225RYSG270	98	366	650.9	368.106	37	132.518
EMR225RYSG285	93	386	650.9	389.422	37	140.192
EMR225RYSG350	75	475	650.9	481.317	37	173.274

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
EMR225RYSG435	60	590	650.9	594.428	37	213.994
EMR225RYSG450	55	610	650.9	648.886	37	233.599
EMR225RYSG535	43	725	1179.7	838.361	37	301.81
EMR225RYSG625	37	848	1179.7	982.694	37	353.77
EMR225RYSG775	30	1051	1179.7	1213.639	37	436.91
EMR225RYSG1050	22	1424	2595.3	1642.500	37	591.3
EMR225RYSG1230	19	1668	2595.3	1925.278	37	693.1
EMR225RYSG1520	15	2061	2595.3	2377.722	37	855.98
EMR225RYGM2400	9	3254	3390.0	4161.097	37	1497.995
EMR225RYGM3000	7	4068	10170.0	5145.833	37	1852.5
150 Series Offset Tools						
EMR150RFOGG7	1140	9	10.5	36.503	35	13.141
EMR150RFOGG9	920	12	10.4	45.342	35	16.323
EMR150RFOGG12	740	16	22.2	56.250	35	20.250
EMR150RFOGG16	585	22	21.9	70.833	35	25.5
EMR150RFOGG20	465	27	35.5	89.197	35	32.111
EMR150RFOGG23	415	31	35.4	100.000	35	36.0
EMR150RFOGG29	330	39	51.0	125.925	35	45.333
EMR150RFOGG33	280	45	50.8	147.964	35	53.267

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
225 Series Offset Tools						
EMR225RFOGG26	970	35	44.2	37.178	37	13.38
EMR225RFOGG33	760	45	62.2	47.456	37	17.08
EMR225RFOGG37	680	50	62.0	53.000	37	19.08
EMR225RFOGG42	595	57	61.6	60.539	37	21.79
EMR225RFOGG50	505	68	93.8	71.442	37	25.72
EMR225RFOGG56	450	76	93.4	79.772	37	28.72
EMR225RFOHGG54	485	73	66.8	71.442	37	25.72
EMR225RFOHGG61	435	83	102.2	79.772	37	28.72
EMR225RFOHGG67	390	91	101.8	88.583	37	31.89
EMR225RFOHGG75	350	102	135.1	98.889	37	35.6
EMR225RFOHGG86	305	117	134.7	112.986	37	40.68
EMR225RFOHGG90	290	122	134.5	119.408	37	42.99
EMR225RFOHGG102	260	138	134.5	133.333	37	48.0
EMR225RFOHGG115	225	156	173.9	152.322	37	54.84
EMR225RFOG122	205	165	230.5	169.575	37	61.047
EMR225RFOG143	175	194	230.0	198.767	37	71.556
EMR225RFOG168	150	228	297.0	232.989	37	83.876

EMT Series Fixtured Tools

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
TT-300-75 SERIES TOOLS						
TT300-75-5V	251	137.7	260.5	319	12	19.92
TT300-75-5X	157	220.0	416.2	509	12	31.83
TT300-75-4V	188	183.7	260.5	425	12	26.59
TT300-75-4X	118	293.5	416.2	680	12	42.48
TT300-75-3V	127	271.9	260.5	629	12	39.34
TT300-75-3X	80	434.4	416.2	1006	12	62.86
TT300-75-2V	95	362.7	346.2	840	12	52.48
TT300-75-2X	60	579.4	551.9	1342	12	83.85
EMT40 SERIES TOOLS						
EMT40-20M	583	28.7	15.9	768	11	12.00
EMT40-10M	292	57.4	49.8	1536	11	24.00
EMT40-10-INLINE	438	38.3	33.2	1024	11	16.00
EMT40-7M	194	86.1	59.9	2304	11	36.00
EMT40-7-INLINE	292	57.4	40.0	1536	11	24.00
EMT40-5-INLINE	206	81.3	33.2	2176	11	34.00

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
EMT80 SERIES TOOLS						
EMT80-10T	463	36.2	157.4	967	11	15.12
EMT80-10P	553	30.3	131.9	811	11	12.67
EMT80-10-INLINE	860	19.5	68.6	521	11	8.14
EMT80-6T	252	66.5	157.4	1780	11	27.82
EMT80-6P	300	55.8	131.9	1492	11	23.31
EMT80-6-INLINE	467	35.8	68.6	959	11	14.98
EMT80-4T	189	88.8	157.4	2376	11	37.12
EMT80-4P	225	74.4	131.9	1991	11	37.10
EMT80-4-INLINE	350	47.8	68.6	1279	11	19.99
EMT80-3T	127	131.4	157.4	3516	11	54.93
EMT80-3P	152	110.1	131.9	2946	11	46.03
EMT80-3-INLINE	237	70.8	69.2	1893	11	29.58
EMT80-2T	96	175.3	170.9	4690	11	73.28
EMT80-2P	114	146.9	131.9	3930	11	61.40
EMT80-2-INLINE	177	94.4	92.2	2525	11	39.46

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
EMT200 SERIES TOOLS						
EMT200-10	614	56.2	196.0	521	12	8.14
EMT200-10T	331	104.5	364.0	967	12	15.12
EMT200-10V	461	75.0	261.3	694	12	10.85
EMT200-10X	289	119.5	416.5	1107	12	17.30
EMT200-5	334	103.5	196.0	959	12	14.98
EMT200-5T	180	192.2	364.0	1780	12	27.82
EMT200-5V	250	138.0	261.3	1278	12	19.97
EMT200-5X	157	220.0	416.5	2037	12	31.83
EMT200-4	250	138.1	196.0	1279	12	19.99
EMT200-4T	135	256.5	364.0	2376	12	37.12

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
EMT200-4V	188	184.1	261.3	1705	12	26.65
EMT200-4X	118	293.5	416.5	2719	12	42.48
EMT200-3	169	204.4	196.0	1893	12	29.58
EMT200-3T	91	379.6	364.0	3516	12	54.93
EMT200-3V	127	271.9	260.7	2518	12	39.34
EMT200-3X	80	434.4	416.5	4023	12	62.86
EMT200-2	127	272.7	260.4	2525	12	39.46
EMT200-2T	68	506.4	364.0	4690	12	73.28
EMT200-2V	95	363.5	261.3	3366	12	52.60
EMT200-2X	60	579.4	553.2	5367	12	83.85
EMT200 WITH ROTOR HEAD						
EMT200-4-4805	117	295.5	419.5	2736	12	42.76
EMT400 SERIES TOOLS						
EMT400-10	1155	67.9	392.0	277	23	4.33
EMT400-10V	866	90.5	522.6	369	23	5.77
EMT400-10X	543	144.3	833.0	589	23	9.20
EMT400-8	833	94.1	392.0	384	23	6.00
EMT400-8V	625	125.4	522.6	512	23	8.00
EMT400-8X	392	199.9	833.0	816	23	12.75
EMT400-5	310	253.2	392.0	1034	23	16.15
EMT400-5V	232	337.6	522.6	1378	23	21.53

Model No.	Catalog Data		Torque Calibration Factor	Angle Calibration Factor	Servo Parameter Set	Gear Ratio
	Max Speed (RPM)	Max Torque (Nm)				
EMT400-5V	232	337.6	522.6	1378	23	21.53
EMT400-5X	146	538.1	833.0	2196	23	34.32
EMT400-4	266	294.3	392.0	1201	23	18.77
EMT400-4V	200	392.3	522.6	1601	23	25.02
EMT400-4X	125	625.4	833.0	2553	23	39.89
EMT400-3	192	407.7	392.0	1664	23	26.00
EMT400-3V	144	543.5	522.6	2218	23	34.66
EMT400-3X	90	866.4	833.0	3536	23	55.25
EMT400-2	139	564.5	541.0	2304	23	36.00
EMT400-2V	104	752.5	522.6	3071	23	47.99
EMT400-2X	65	1199.6	833.0	4896	23	76.50
EMT600 SERIES TOOLS						
EMT600-3	149	537.1	600.0	2148	23	33.57
EMT600-2	102	781.5	781.5	3126	23	48.84
EMT800 SERIES TOOLS						
EMT800-2	102	1074.9	1124.1	3126	28	48.84

SECTION 18
Recommended Spare Parts

Item Number	Cooper Part Number	Qty	Description
1	577004-X	1	Fixtured Spindle **Tool Cable**, Standard (X=length in feet)
1A	577003-X	1	Fixtured Spindle **Tool Cable**, Hi-Flex (X=length in feet)
2	542778-X	1	Handtool **Tool Cable** (X=length in feet)
3	576191	1	**SUBCON Connector for Public I -O**. Female 25 pin D shell with terminal blocks. Mates with T3M Enclosure Public I-O connector for customer application.
4	576211	1	**SUBCON Connector for Private I -O**. Male 25 pin D shell with terminal blocks. Mates with Private I-O connector for customer application.
5	572636	1	**Keyboard**, 88 keys, includes touchpad
6	576140	1	Indicator **Light Board** Assembly including bulbs, LCD brightness adjust circuit and connectors
7	576155	6	**Indicator Lamp**, 14 volts, 100 ma, 10,000 hour, wire terminals.
8	572660	1	**PC-104 I/O Module** (8 input, 8 Output) Optocoupler Digital Inputs and Relay Outputs.
9	575933	1	**DeviceNet** Board, PC-104. Slave
10	576165	1	8.4 inch XGA TFT Digital **LCD Display** Panel 1024 x 768 pixels
11	576176	1	Inverter DC to AC **Inverter**, Low Profile, Off-board Dimming, Dual Tubes Output
12		1	Profibus Board, PC-104 Slave
13		1	Interbus Board, PC-104 Slave
14		1	RS-232 Serial Connection Port Option